WINGS OF FAME™

THE JOURNAL OF CLASSIC COMBAT AIRCRAFT

VOLUME 14

WINGS OF FAME™

Aerospace Publishing Ltd
AIRtime Publishing Inc.

Published quarterly by
Aerospace Publishing Ltd
179 Dalling Road
London W6 0ES
UK

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1999

ISSN 1361-2034
Aerospace ISBN 1 86184 029 2
(softback)
1 86184 030 6
(hardback)
AIRtime ISBN 1-880588-23-4

Published under licence in USA and
Canada by AIRtime Publishing Inc.,
10 Bay Street, Westport,
CT 06880
USA

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Origination by
Chroma Graphics, Singapore
Printed by
Officine Grafiche DeAgostini,
Novara, Italy

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For their assistance in the preparation of this volume of *Wings of Fame*, the authors and publishers gratefully acknowledge the assistance of the following:

The Glenn L. Martin Museum, Baltimore and Stan Piet for their assistance with photographs for the XB-51 article.

Air Commodore Graham Pitchfork (retd) for his assistance with the Buccaneer article. The author would further like to add his thanks to the members of the Buccaneer Aircrew Association and friends within the Royal Air Force and in the aviation industry. All views expressed, though, are the author's own.

Robert F. Dorr, Don Segner, Dave Ostrowski, Norman Polmar and Skip Robinson for help with the AH-56 Cheyenne article.

Special thanks to Chuck Worman of the USAF Museum, who took a special interest in the search and rescue mission and took the time to share some of it with Larry Davis.

The editors of WINGS OF FAME™ welcome photographs for possible publication, but cannot accept any responsibility for loss or damage to unsolicited material.

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Wings of Fame™ is published quarterly and is available by subscription and from many fine book and hobby stores.

SUBSCRIPTION AND BACK NUMBERS:

UK and World (except USA and Canada) write to:
Aerospace Publishing Ltd
FREEPOST
PO Box 2822
London
W6 0BR
UK
(No stamp required if posted in the UK)

USA and Canada, write to:
AIRtime Publishing Inc.
Subscription Dept
10 Bay Street
Westport
CT 06880, USA
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Toll-free order number in USA:
1 800 359-3003

Prevailing subscription rates are as follows:
Softbound edition for 1 year:
$59.95
Softbound edition for 2 years:
$112.00
Softbound back numbers (subject to availability) are $16.00 each, plus shipping and handling. All rates are for delivery within mainland USA, Alaska and Hawaii. Canadian and overseas prices available upon request. American Express, Discover Card, MasterCard and Visa accepted. When ordering please include card number, expiration date and signature.

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An Industry of Prototypes

Martin XB-51

Following its unveiling in 1949, the Martin XB-51 was hailed by the influential American aviation magazine *Aviation Week* as the "most unconventional jet design yet produced in the US." However, despite its many remarkable features, the XB-51 was destined never to enter production. Designed as a close air support aircraft, it fell victim to the demands of the conflict in Korea and the need to rapidly reverse the decline of US tactical air power in the aftermath of World War II.

The origins of the Martin XB-51 can be traced to military characteristics outlined in a requirement for an attack aircraft first issued in November 1944 by the US Army Air Forces. The 'attack' classification was initially introduced by the (then) US Army Air Service in May 1924 in order to denote aircraft intended to provide low-level close support for ground forces. In the inter-war period, attack aircraft developed into a category of single- and twin-engined aircraft distinct from their pursuit (fighter) and light bombardment counterparts. However, during World War II rapid developments in US combat aircraft design, combined with the maturation of USAAF doctrine and tactics, led to the blurring of the divisions between attack, light bombardment and fighter aircraft. Although the USAAF did use single-engined attack aircraft in small numbers during the conflict – notably, the North American A-36 Apache, a derivative of the P-51 Mustang – the ground attack task had fallen largely to 'fighter-bombers' armed with bombs or rockets.

The Martin Model 234/XB-51 programme amounted to just two aircraft, both of which are seen here (46-685 on the left) over Martin's runway in October 1950, flown by USAF test pilots Russ Schleeh and Lee Horn.

Twin-engined attack aircraft

By contrast, attack aircraft had become larger twin-engined machines, armed with heavier bomb loads and equipped to bomb from medium as well as low altitude. The last – and by far the most advanced – of these to enter USAAF service during World War II was the Douglas A-26 Invader. Designed by the legendary Ed Heinemann to replace the Douglas A-20 Havoc (another Heinemann product), the A-26 first flew on 10 July 1942. Despite production delays (which led General Arnold to remark at one point that he would like the A-26 "for use in this war and not for the next war") and initial teething problems on being rushed into service, the Invader was to prove itself an outstanding combat aircraft. While the range and bombload of the A-26 were comparable with the USAAF's larger North American B-25 Mitchell and Martin B-26 Marauder, the Invader's top speed was approximately 60 mph (96 km/h) faster than that of the medium bombers.

It was against this background that the USAAF issued military characteristics for a new

XB-51 number one, 46-685, has an Air Force Flight Test Center badge applied below its cockpit in this view. Above the 'AIR' in the 'U. S. AIR FORCE' legend, the remnants of the name Ernie's Pride may be seen. The type was never officially named, though some sources note that 'Panther' was suggested.

attack aircraft. From the many submissions received, three main contenders were to emerge: Curtiss, Convair and Martin.

Curtiss's XA-43 design resembled the company's response to a USAAF specification for a single-seat, twin-jet all-weather fighter; although the latter had been rejected by the Army Air Force in March 1945, Curtiss had been granted permission to proceed with its attack aircraft proposal (the Curtiss Model 29). This decision was effectively reversed on 21 November 1945, when Curtiss was authorised to transfer funding from the XA-43 to the manufacture of two prototypes of a two-seat, four-engined all-weather fighter, the Curtiss Model 29A; this became the XP- (later, XF-) 87 Blackhawk. Despite the placement of contracts for 88 production F-87A fighters and 30 examples of a reconnaissance derivative during June 1948, flight test difficulties combined with the performance of the Northrop F-89 Scorpion led the USAF to cancel the programme on 18 October 1948.

Convair's design to meet the USAAF's military characteristics – the XA-44 – was more radical. Inspired by reports of German aerodynamic developments, Convair proposed an aircraft with forward-swept wings and powered by three jet engines. Funded by

Rolled out on 4 September 1949, the first XB-51 represented a massive leap forward both in technology and appearance over Martin's most recent bomber prototype, the XB-48, which had flown for the first time during 1947.

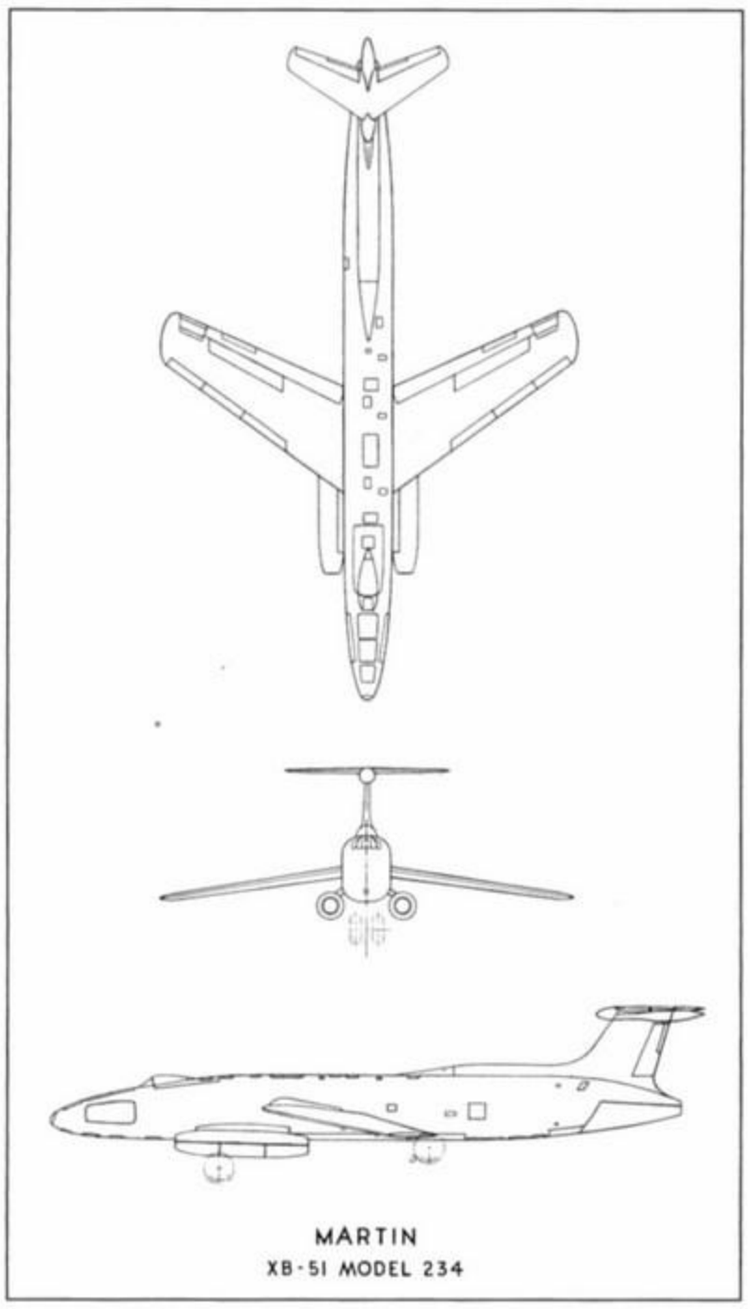
Right: Seen beneath 46-685 on 15 December 1949, Glenn L. Martin's chief test pilot, O. E. 'Pat' Tibbs (left), chats with Lieutenant Tom Collins, USAF (centre) and Martin's XB-51 project test pilot, Frank Christofferson. More than one test pilot remarked that the XB-51 was one of the most trouble-free pre-production aircraft they had flown and an impressive performer, with an excellent roll rate and turn of speed. When it first flew, the type was faster than any other type in the USAF, with the exception of the F-86 Sabre.

money drawn from the XB-46 programme, development of the XA-44 continued and in 1948 the aircraft was redesignated the XB-53. Bomber and attack configurations of the XB-53 were prepared, featuring forward-swept wings with variable-incidence tips and powered by three General Electric J35 engines housed in the fuselage. Although two XB-53 prototypes were authorised, the project was cancelled before either had been completed.

The third submission came from the Glenn L. Martin Company. A straight-winged machine weighing some 70,000 lb (31750 kg), the Martin XA-45 was to have been powered by a combination of two TG-110 turboprops and two I-40 (service designation J33) turbojets giving a projected maximum speed of 525 mph (845 km/h), a cruising speed of 325 mph (523 km/h), and a combat radius of 800 miles (1287 km). The armament of the XA-45 echoed the wartime merging of the attack and bombardment classes; the maximum bombload of the XA-45 design was to be some 8,000 lb (3630 kg) and, in order to deliver this load accurately, the aircraft was to be fitted with high-altitude bombing equipment. The Martin design included comprehensive defensive armament and carried a crew of six.

XA-45 wins 1946 competition

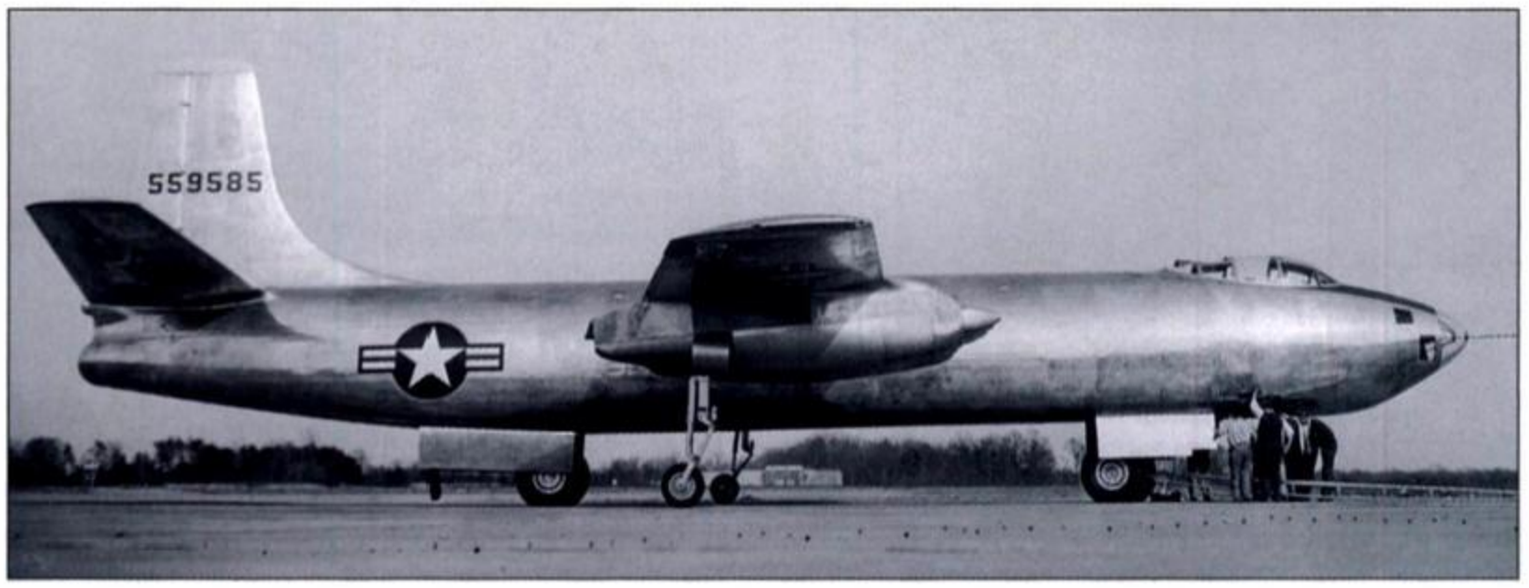
The Martin XA-45 emerged as the winner from a design competition held in February 1946. The aircraft was proposed to the Air Material Command on 1 April 1946, and on 23 May Martin was awarded a $9.5 million fixed-price letter contract for the manufacture of wind-tunnel models, mock-ups, and two prototypes, to be designated the Martin XB-51. However, even at this stage the nature of the USAAF's requirement was by no means certain. The military characteristics underpinning the XB-51 were revised during the spring of 1946;



***Above:** Between initial design and construction, the aircraft was lengthened by 5 ft to offset a predicted tendency to Dutch roll.*

Above:** Converted from the last but one **B-26G-25**, the sole **XB-26H** (later **ZXB-26H**) was intended to test the validity of the tandem main landing gear concept, as incorporated in Martin's **XB-48**, its Boeing competition (the **XB-47**) and the **XB-51**. External ribbing was applied to strengthen the fuselage, which was now expected take the full force of a landing on the new undercarriage. Serialled 44-68221, the aircraft was otherwise known as* **Middle River Stump Jumper.

***Below:** A conventional and, compared with its rivals, outmoded design, the Model 223 **XB-48** was Martin's most recent attempt to produce a medium bomber. This aircraft was one of two built.*



despite this, doubt remained among planners in the Army Air Force Headquarters that the aircraft would adequately fulfil the light bomber role. The possibility of seeking one or more new designs from other manufacturers was considered, only to be rejected on the advice of the Air Material Command.

With the XB-51 project effectively held in abeyance for much of 1946, Martin conducted a series of studies into alternative designs, drawing at least in part on the fruits of captured German research. This led to the emergence of a radically different proposal from that selected by the Air Force in February 1946. Intended primarily for Army support operations, the revised XB-51 design deleted the high-altitude bombing apparatus and defensive armament carried by the earlier aircraft; one consequence of this was to reduce the number of crew required from six to two. Initially, the maximum speed of the reworked XB-51 was projected to be 620 kt (713 mph; 1150 km/h), with a cruising speed of 463 kt (532 mph; 856 km/h); following further studies conducted by Martin at the behest of the Air Material Command, these were reduced to 521 kt (600 mph; 964 km/h) and 434 kt (500 mph; 803 km/h), respectively. Radius of action was greatly scaled down, at 378 miles (608 km). However, given that the primary navigational aid of the new aircraft was to be AN/APN-3 SHORAN (SHOrt RAnge Navigation – a radio navigation aid using signals transmitted from ground-based transmitters), with a range of less than 200 nm (230 statute miles; 370 km), this was not at this stage deemed to be a serious disadvantage. The armament of the XB-51 was to consist of a bombload of 4,000 lb (1815 kg), augmented by eight forward-firing cannon.

Design work commences

The Army Air Force Headquarters approved new military characteristics based on the revised XB-51 design prepared by Martin on 31 January 1947 and design work on the Model 234 (the company designation for the XB-51) commenced on the following day. On 13 September 1947 Martin received permission to proceed with basic engineering and with the construction of a mock-up of the aircraft. The latter was inspected by the Air Force between 24-27 February 1948 and subsequently, on 23 April, Martin was granted permission to proceed with Phase II design work.

The first prototype of the Martin XB-51 (serial number 46-685) was built at the Martin factory at Middle River, Maryland, and officially rolled out on 4 September 1949. The

This early photograph of the first aircraft shows its large flaps and considerably smaller 'trimming ailerons'. Also visible on the nose of the aircraft is the original version of the 'Martin XB-51' legend, later redesigned and repositioned further forward.

With its unusual engine placement, tandem undercarriage and pronounced mainplane anhedral, the XB-51 looked ungainly on approach. Here the aircraft's tiny outrigger wheels may be seen, along with its massive flaps, lowered for landing.

physical appearance of the new aircraft was unlike any then seen from a US manufacturer. A mid-wing all-metal monoplane with swept wings and a T-tail, the XB-51 had an overall length of 85 ft 1 in (25.9 m) and wing span of 53 ft 1 in (16.2 m). The empty weight of the airframe was 29,584 lb (13420 kg) and the laden weight 59,467 lb (26975 kg).

A detailed examination of the aircraft shows that the XB-51 combined elements drawn from earlier Martin aircraft with a number of innovations. One feature shared with the earlier Martin B-26 Marauder was the employment of comparatively small wings, with correspondingly high wing loadings; the wing area of the XB-51 was only 548 sq ft (51 m^2), giving a wing loading of approximately 100 lb per square foot, which minimised gust response at low level. The design of the wing also owed something to that of Martin's earlier XB-48 insofar as it was designed to be as thin as possible, with all fuel and the main undercarriage units being housed in the fuselage.

In contrast to the XB-48, the wing of the XB-51 was swept to 35° and had an anhedral of 6°. The wing profile was the NACA-63A-101, with a mean chord of 130.7 in (332 cm) and a 10 per cent thickness-to-chord ratio. Lateral control was afforded by a combination of large one-piece spoilers immediately ahead of the flaps (an arrangement also employed on the XB-48), combined with small 'trimming ailerons' at the wingtips to enable the pilot to gain some feedback through the control system. Lift devices were hydraulically driven, including single-slotted flaps occupying much of the trailing edge and semi-automatic slats over 69 per cent of the leading edge; the latter could be opened either automatically via an angle of attack sensor or manually by the pilot.

One of the most striking features of the XB-51 was the employment of a variable-incidence system. The incidence of the wings could be varied from +2° to +7° 30', +3° usually being selected in normal flight and +7° for take-off and landing. In contrast to earlier attempts to achieve a practical system for changing wing incidence – which had sought to rotate the wing about the front spar – the XB-51's wing was mounted on bearings at the rear, with front-mounted irreversible hydraulic jackscrews to move the front of the wing through the incidence range.

Bicycle undercarriage

Variable incidence enabled the XB-51 to adopt a horizontal landing profile more suited to the aircraft's bicycle undercarriage. The undercarriage itself was an improved version of that fitted to the XB-48, being simpler, lighter and easier to control. Steering on the ground was via the forward undercarriage unit, while outriggers ensured that the aircraft did not topple while taxiing; these retracted forwards into the wing in flight.

In order to ensure that the XB-51's wing was as aerodynamically clean as possible, many of the additional elements often associated with the wing structure – notably, the fuel, engine and undercarriage systems – were placed in or attached to the XB-51's comparatively large fuselage. JP-3 fuel for the three 5,200-lb st (23.13-kN) thrust General Electric J47-GE-13 axial-flow jet engines was contained in three tanks, with a maximum of approximately 2,835 US gal (10730 litres) being carried. For ferrying, two further tanks carrying an additional 700 US gal (2650 litres) could be fitted in the bomb bay. Two of the three engines were hung on pods on each side of the lower fuselage forward of the wing, while the third was buried in the tail and fed by a gently curving duct leading from an intake on the top of the fuselage. Engine take-off performance was boosted by water/alcohol injection; four RATO bottles could also be fitted to the rear fuselage, providing an extra 1,000 lb (4.45 kN) of thrust.

The tail has been described by one author as a "structural and aerodynamic *tour de force*." Placing the tailplane atop the fin served to boost the effect of the fin itself, thereby permitting it to be reduced in size. The XB-51's elevators and rudder were hydraulically boosted, and the tail itself could be turned either to serve as the primary control surface when recovering from high-Mach dives or to trim the aircraft at normal flight speeds. Although not originally fitted, a bullet-shaped fairing was added to the first prototype at the junction between the fin and the tailplane, in order to eliminate aircraft vibration and elevator roughness at high speeds, with an identical blister being fitted to the second XB-51 during manufacture. The tail incorporated a brake parachute ejected from a door on the right side of the base of the rudder. A door-type airbrake was fitted to the underside of the rear fuselage; it was primarily used to change the glide path angle.

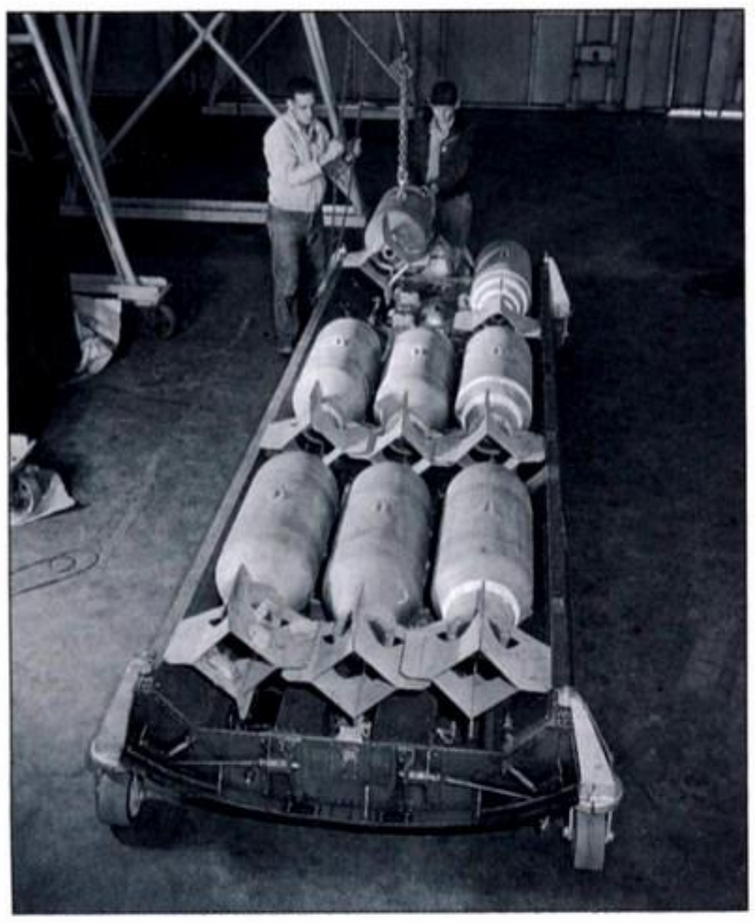
In addition to a single pilot, the XB-51 carried a radio/SHORAN operator. The pilot's cockpit was placed on the centreline of the aircraft under a streamlined fighter-type jettisonable (but not opening) canopy. By contrast, the operator sat on the right-hand side of the rear cockpit, his exterior view being restricted to a small window on the right-hand side of the airframe. Ejection seats were provided for both crew members. The main avionics bay was placed under the cockpit floor and around the operator's position. As already noted, the primary navigation aid carried by the XB-51 was AN/APN-3 SHORAN; the aircraft was also fitted with an AN/ARN-6 radio compass, AN/APT-16 radio counter-measures (RCM) equipment, VHF radio, radar and marker beacons. However, no radar was fitted.

The XB-51 packed a formidable punch. Internal bomb stowage was provided via a detachable rotating bomb bay door; the

Above: Accompanied by an RF-80 chase aircraft, 46-685 arrives at Patuxent NAS after its first flight. The variable-incidence wing gave the aircraft a very flat attitude when landing.

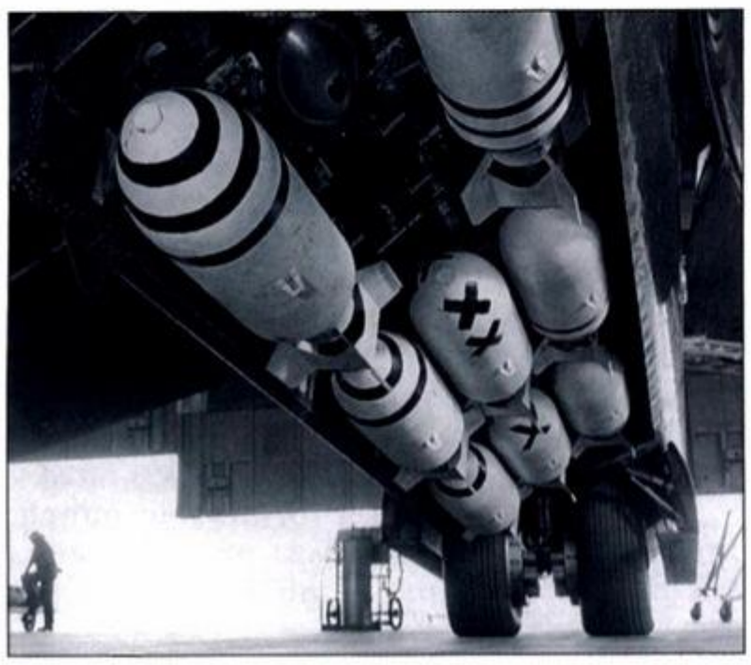
Right: Smoke pours from 6685's three GE J47s as it roars into the air on its first flight, on 28 October 1949. Note the pair of RATO bottles on the rear fuselage.

The second prototype, seen here with various weapons options being arranged before it, became the weapons trials ship for the XB-51 programme. Not shown are the 160 rounds for each of the eight 20-mm cannon.



Left: The XB-51's rotary weapons bay (in effect a carrier-cum-bomb bay door) was an innovation, solving the buffet problems created by conventional bomb bay doors. Though its future with the XB-51 was limited, the rotary weapons bay design found its way onto the B-57 Canberra and was adopted by Blackburn Aircraft for its Buccaneer strike aircraft. Here, nine 500-lb bombs are loaded aboard carrier/door.

Below left: Rotating though 180°, the bay was able to carry up to 6,400 lb (2903 kg) of bombs internally, dictated by the type of ordnance available. With 4,000 lb (1814 kg) able to be carried externally, the aircraft had a total weapon load capacity of 10,400 lb (4717 kg). Designed for easy removal, the weapons bay shortened the time needed to reload, this being accomplished simply by replacing the bay.



Below: Weapons bay dimensions limited internal capacity for 1,600-lb or 2,000-lb bombs to four and two, respectively. To take advantage of the B-51's load capacity, two extra bombs (2,000-lb examples seen here) could be fixed externally.

aircraft's weapon load was attached to the underside of the door, which pivoted through 180° prior to bomb release. This elegant design resolved the problem of turbulence around the weapons bay, and was patented by the Martin armament engineers who developed it. As an alternative to the standard door, a bulged door could be fitted to permit the carriage of larger weapons. To prevent bombs tumbling in the XB-51's slipstream on release – a common problem – actuators powered by compressed air pushed each weapon away from the rack in which it was mounted. The maximum bombload of the XB-51 was 10,400 lb (4717 kg); alternatively, eight 5-in High-Velocity Aircraft Rockets (HVARs) could be carried in the bomb bay. Gun armament comprised no fewer than eight 20-mm cannon grouped in the nose, with a total of 1,280 rounds of ammunition. The nose also contained a forward oblique strike camera, and the XB-51 carried a vertical reconnaissance camera and a rearwards-facing battle damage assessment camera fitted aft of the rear undercarriage gear. To accurately deliver the weapons carried by the XB-51, the

An alternative to bombs was a load comprising eight 5-in High-Velocity Aircraft Rockets (HVARs), fixed to a special pallet within the weapons bay.

pilot was provided with an A1B gun-, rocket- and bomb- sight with radar ranging.

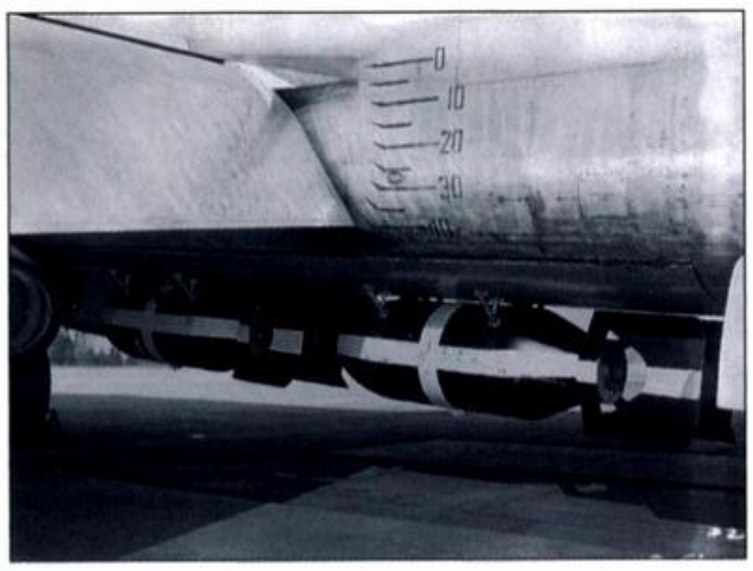
Taxi tests and maiden flight

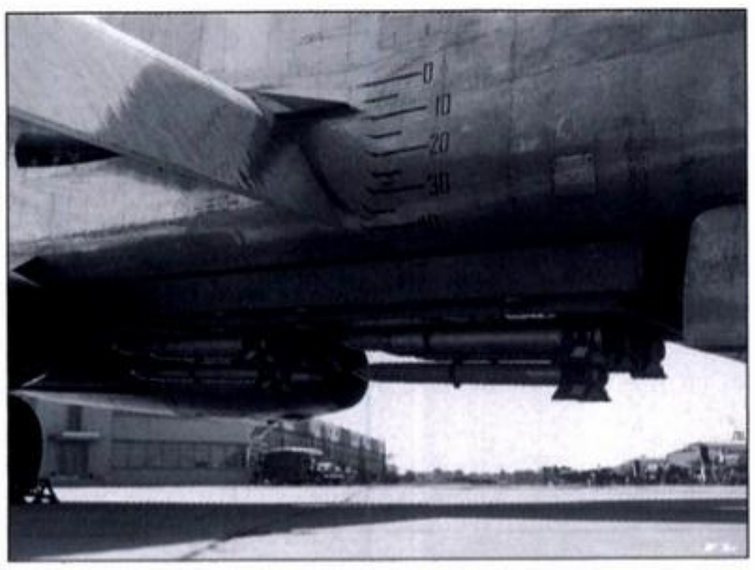
Taxi tests of the first prototype XB-51 began on 17 September 1949. The 34-minute maiden flight of 46-685 took place between Middle River and Patuxent Naval Air Station, Maryland on 28 October, with Martin chief test pilot (and Korean War ace) E. O. ('Pat') Tibbs at the controls. Following this flight, Martin received a definitive development contract for the production of two prototypes on 1 November 1949.

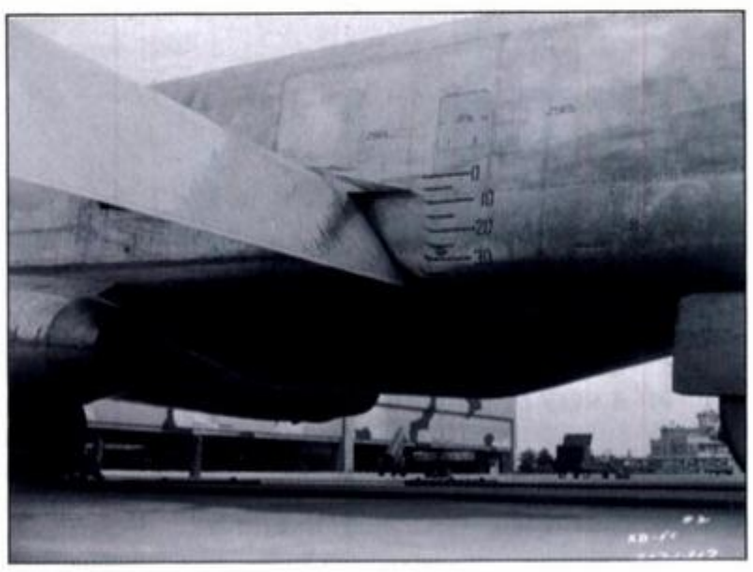
Phase I (Air Worthiness) testing of the XB-51, conducted by Martin pilots, was completed by the end of March 1950. Phase II (Contractor Compliance) testing was undertaken by USAF test pilots between 4 April and 10 November 1950. During this period 46-685 was joined by the second prototype – serial number 46-686 – which made its first flight on 17 April 1950. Despite the emergence of certain aerodynamic and systems problems – rapidly addressed by Martin – the performance of the XB-51 would appear to have impressed the Martin and USAF test pilots attached to the programme. A report of a visit to USAF test establishments and aircraft factories in November-December 1950 by two Royal Air

Above: Useful ground attack/close support weapons, fragmentation bombs (here in 500-lb clusters) were another option.

Below: In order to allow the carriage of a single 4,000-lb bomb, Martin designed this oversized so-called 'B-type' bulged weapons bay.







Though production of the XB-51 was cancelled in late 1951, 46-685 joined the USAF early the following year, only to crash in February. With the subsequent loss of the second aircraft, 6685 was repaired by Martin at USAF expense and employed as a bomb release trials aircraft during 1953 and 1954, and starred as the 'Gilbert Fighter' in a Hollywood motion picture. During this period 6685 flew with high-visibility Dayglo patches on the underside of its nose and outer wings, as seen in this 1955 view. In 1956 it went the same way as 6686, wrecked in an accident on 25 March.

Force officers – Squadron Leader R. F. W. Cleaver of the Aeroplane and Armament Experimental Establishment (A&AEE), Boscombe Down, and Flight Lieutenant W. J. O. Morrison of the Royal Aircraft Establishment (RAE), Farnborough – provides a snapshot of the performance of the aircraft at the end of Phase II testing:

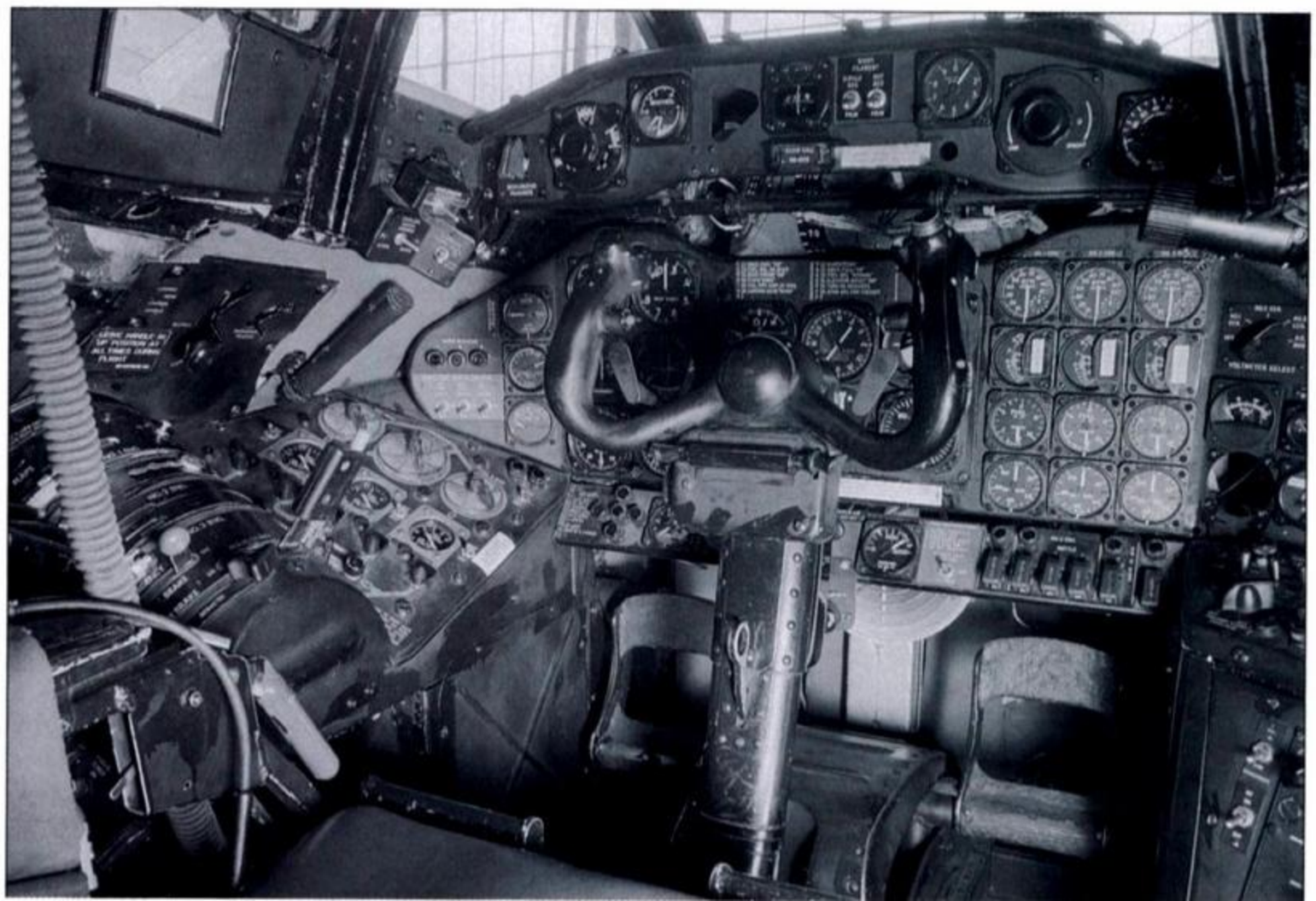
"The range was 8-900 miles at 15-20,000 ft. The service ceiling was 40,000 ft but 30,000 ft was the tactical ceiling limited by manoeuvrability. Wind tunnel prediction of tail surfaces flutter imposed a speed of 620 mph at sea level which was attained at 0.93 per cent rpm. At this speed there was some rudder pedal vibration which had caused no measurable directional oscillation. Mach 0.9 had been achieved in level flight at 20,000 ft. Stick force/g at 620 mph IAS was 40 lb. Rudder and elevator forces were high, elevator control, only, being boosted. The clean stalling speed was 170 mph at maximum AUW. The angle of approach could be steep. Touch-down speed was 140 mph at normal weight, but a run of only 800 yd was required to become airborne at maximum weight."

Even as the XB-51 was undergoing flight testing, events were conspiring to focus attention on the USAF's tactical capability. The US Army Air Force had ended World War II with tactical air assets unprecedented in their size and capability. Nevertheless, uncertainty surrounded the continued relevance of tactical air power in the new nuclear age; as early as August 1945, Major General Lauris Norstad – then Chief of the Air Staff, Plans – noted that the atomic bomb could have rendered tactical forces "as old-fashioned as the Maginot Line". In a world dominated by atomic weapons, US planners envisaged that the primary role of the Air Force in any future role would be to deliver the new weapons of mass destruction; only if an all-out atomic assault failed would tactical air forces be required.

Budgetary restrictions

Moreover, post-war budgetary restrictions hobbled the development of the newly independent US Air Force; although planning for the new service had envisaged a peacetime Air Force of 70 groups, upon achieving independence in September 1947 the USAF only consisted some 48 groups. This, combined with the rapidly increasing unit cost of jet aircraft in comparison with their piston-engined equivalents, served to force the USAF to concentrate on the procurement and operation of aircraft to fulfil key roles – to the detriment of other tasks deemed of lesser importance.

One consequence of this reorientation of US air power was the dramatic reduction in strength and importance of US tactical air forces. The tactical bomber force was hard hit; while in January 1946 the US Army Air Force inventory included 3,353 medium bombers and 2,343 attack aircraft, by June 1950 this had dwindled to a mere 762 Invaders (redesignated the B-26 in June 1948 with the withdrawal of the last Martin B-26s from USAF service). Such a wholesale reduction in the USAF's ability to support the US Army Field Forces was viewed with grave disquiet in some quarters. During the late 1940s, the USAF came under increasing pressure from the US Army to increase the resources available for tactical air support; particular emphasis was placed on the deployment of new attack aircraft. The XB-51 was seen by the Army as an excellent aircraft to fill this need. An *Aviation Week* report published on 2 October 1950 reported that the "Glenn L Martin Co.'s three-jet XB-51 is favoured by the Army as the nearest approach to its requirements as a tactical air support weapon. It was recommended that if procurement of the XB-51 cannot be accomplished by USAF then certain design features of the plane



The XB-51 was only marginally slower than an F-86 and at least one test pilot noted that it handled like a fighter. Its cockpit no doubt reinforced this fighter-like impression. An XB-51's two crew (pilot and radio/SHORAN operator) gained entry to the aircraft (in this case, 46-686) via a small ventral hatch with an integral stairway, beneath the forward fuselage. Once inside they climbed through a floor hatch into the pressurised crew compartment. The pilot sat in an ejection seat under the non-opening, but jettisonable, teardrop canopy. The radio operator was positioned to the right of the centreline below and behind the pilot, and viewed the outside world via a small circular window on the right side of the aircraft. An ejection seat was also provided for the backseater, this firing through a jettisonable roof hatch.

Airflow problems over the tailplane were solved by adding a 'bullet' fairing at the intersection of the fin and tailplane. This was retrofitted to 6685; 6686 was built with the feature. Other teething troubles requiring attention from Martin engineers included correct adjustment of the engine's variable exhaust nozzles to achieve the correct exhaust gas temperature. The red line below the rudder indicated the position of the No. 2 turbojet's high pressure blades, such was the concern during the early days of jet propulsion that blades might be shed under power.

be incorporated in a current production light bomber."

The need for a new attack aircraft was further emphasised by the outbreak of the Korean War on 25 June 1950. The USAF's Far East Air Forces (FEAF) was heavily committed to ground support operations throughout the conflict in Korea. These took two main forms. Firstly, FEAF provided close air support in the field, using fighter-bombers such as the F-51 Mustang and the F-80 Shooting Star. Secondly, the USAF sought to impede the North Koreans' ability to conduct operations in the field through interdiction – the prevention of enemy troops and supplies reaching the front line, by attacking them *en route* and by attacking the lines of communication down which they had to pass.

FEAF rapidly asserted its ability to interdict North Korean movements by day. An object lesson to the North Koreans as to the perils of daylight came on 10 July 1950. A flight of F-80s located a column of North Korean vehicles queuing nose-to-tail at a destroyed bridge; calling for assistance, they were rapidly joined by other USAF fighter-bombers and proceeded to wreck the column, claiming 38 tanks, 117 trucks and seven half-tracks destroyed.

Faced with the threat of attack from USAF fighter-bombers by day, the North Koreans resorted to moving at night. This highlighted a major gap in the USAF inventory – the absence of an aircraft suited to the demands of carrying out night interdiction missions. Fighter-bombers lacked the endurance to loiter over roads and railway lines while hunting down convoys and trains; moreover, the F-80s were too fast to permit their pilots to acquire fleeting targets. Although slower, the F-51's wing guns produced muzzle flash that blinded the pilot when they were fired. Given the paucity of F-82 Twin Mustangs in FEAF, the task of night intruding fell almost by default to the two USAF wings in Korea equipped with the B-26 Invader – the 3rd and 452nd Bombardment Wings.

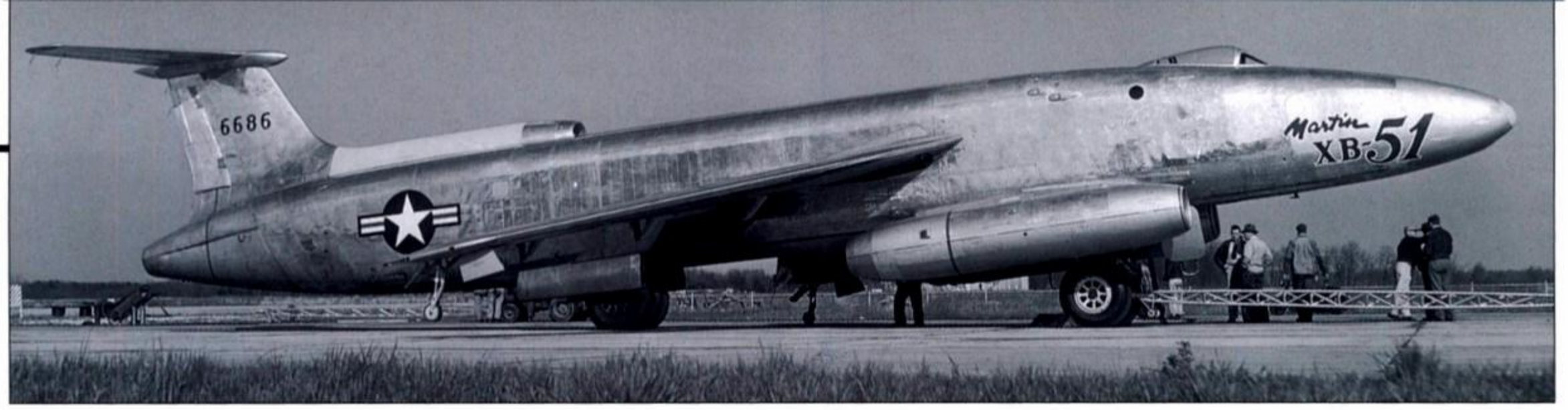
The use of the Invader as a night intruder was far from new, for the aircraft had been employed in this role during the latter stages of World War II. Nevertheless, despite the apparent success of the 3rd and 452nd Wings, it was rapidly recognised that the Invader was less than ideal for the interdiction task in Korea. In part, this related to the performance of the aircraft. However, the main deficiency of the B-26 was identified as the lack of an onboard sensor system enabling it to find its targets. According to FEAF's own Report on the Korean War, released in March 1954, "the B-26 was not entirely satisfactory, nor particularly effective, in its imposed role of night intruder. This was due fundamentally to a lack of equipment capable of detecting, identifying, and attacking pinpoint moving targets at night. Results were dependent on the aggressiveness, skill and experience of the crews, who operated under adverse weather and terrain conditions, and were inescapably limited by the relatively light logistic requirements of a static Communist ground force during most of the last two-thirds of the war."

Night intruder competition

Spurred on by events in Korea, the USAF began a rapid search for a new, advanced night intruder. The overriding need to procure an aircraft quickly – both to augment the USAF's tactical air power in the event of a drawn-out conflict and to compensate for the rapidly dwindling stock of B-26 attrition replacements – led the USAF to conclude that the new intruder should be based on an existing design purchased 'off the shelf'. The USAF Board of Senior Officers began to seriously consider the issue of a B-26 replacement during the summer of 1950, and by September of that year an outline requirement for such an aircraft had been drawn up. Ideally, any future intruder would have a cruising speed of approximately 400 kt (460 mph; 740 km/h), a maximum speed of approximately 550 kt (632 mph; 1017 km/h), a radius of action of around 1,000 nm (1,150 miles; 1952 km), and a service ceiling in the region of 40,000 ft (12192 m). Armament of the intruder was to comprise a bombload of six to 10 500-lb bombs and between six and 10 0.50-in machine-guns or their equivalent; rockets could also be carried. By the end of that year a shortlist of five aircraft judged suitable for conversion to the intruder role had been drawn up: the Martin XB-51, North American B-45

Above: Take-off in 'hot-and-high' conditions and/or at maximum weights was assisted by a set of four RATO bottles with a 14-second burn, attached in pairs on each side of the No. 2 engine.

Right: Though the aircraft's Decelostat anti-skid brake system was very effective, landing runs could be shortened further by deploying a drag 'chute, housed beneath the rudder.



The second XB-51, 46-686, seen at roll-out (right), took to the air on 17 April 1950. After a little over 64 hours of test flying, mainly by F. E. Christofferson, the machine was accepted by the USAF on 8 December 1951. Engaged in armament trials (the aircraft having its full complement of eight 20-mm nose-mounted cannon) and high-speed test flying at Edwards AFB, 6686 amassed just 151 flying hours in all, before crashing fatally while flying from the California base on 9 May 1952. Major Neil H. Lathrop, USAF reportedly attempted a roll at low level, from which he failed to recover.

Tornado, North American AJ Savage, Avro Canada CF-100 Canuck and English Electric Canberra.

From this field emerged two front-runners. The XB-51 had already gathered a groundswell of support within US aviation circles, and was seen by many as likely to receive a production contract. The other main contender was the Canberra, which had impressed many at home and overseas with its performance and manoeuvrability. In August-September 1950, a group of Air Force officers and officials led by Brigadier General Albert Boyd of Air Material Command – then commander of the Air Force Flight Test Center at Edwards Air Force Base – visited the UK to conduct a preliminary review of the Canberra; although favourable, their report was not conclusive.

Canberra or XB-51?

Subsequently, a committee chaired by the Deputy Commander of Air Proving Ground Command (Brigadier General S. P. Wright) was formed by the Board of Senior Officers to select an aircraft from the shortlist. Ruling out the B-45, the AJ and the CF-100, the Wright Committee concluded on 15 December 1950 that the USAF should immediately endeavour to procure both the Canberra and the XB-51. The committee recommended that as an initial step sufficient examples of both types should be obtained to equip two bomb groups; once the B-51 had entered full-scale production, a further order should then be placed to enable the Canberra-equipped groups to be rearmed with B-51s.

However, this recommendation did not find favour among the Air Staff. Although the XB-51 was markedly faster than the Canberra, a number of factors weighed in favour of the latter; these included the Canberra's greater range and excellent agility at low level – both vital in the night intruder role – and the spaciousness of the Canberra's fuselage, which would enable it to carry much-needed night sensors as and when they became available. In the words of USAF historian Marcelle Size Knaack, "The Wright Committee's suggestion aroused scant enthusiasm among the Air Staff members. The Board of Senior Officers, after studying the Air Proving Ground Command's latest evaluations, found itself liking the Canberra's performance. In contrast, it seriously doubted that the B-51's range could ever match the Canberra's radius of action." Believing the Wright Committee to be biased in favour of the XB-51, the Board of Senior Officers put aside its recommendation and instead looked to the Canberra only to fulfil the USAF requirement for an intruder.

While already leaning towards the Canberra, the Board was unwilling to make a final decision between the two aircraft until an example of the British bomber could be acquired for detailed analysis. Accordingly, on 21 February 1951 Canberra B.Mk 2 WD932 was flown across the Atlantic by an RAF crew from A&AEE Boscombe Down, thereby becoming the first jet aircraft to make an unrefuelled crossing of the Atlantic. Five days later, all of the candidates were put through their paces before the Board of Senior Officers at Andrews AFB. Tasked to fly a set number of manoeuvres within a fixed time of 10 minutes, the Canberra (flown on this occasion by the chief test pilot of English Electric, Wing Commander R. P. Beamont) put on a dazzling display, easily completing the set routine with time to spare. Following the fly-off, the Board of Senior Officers recommended that the Canberra be ordered, a decision ratified by the Chief of Staff, General Vandenberg.

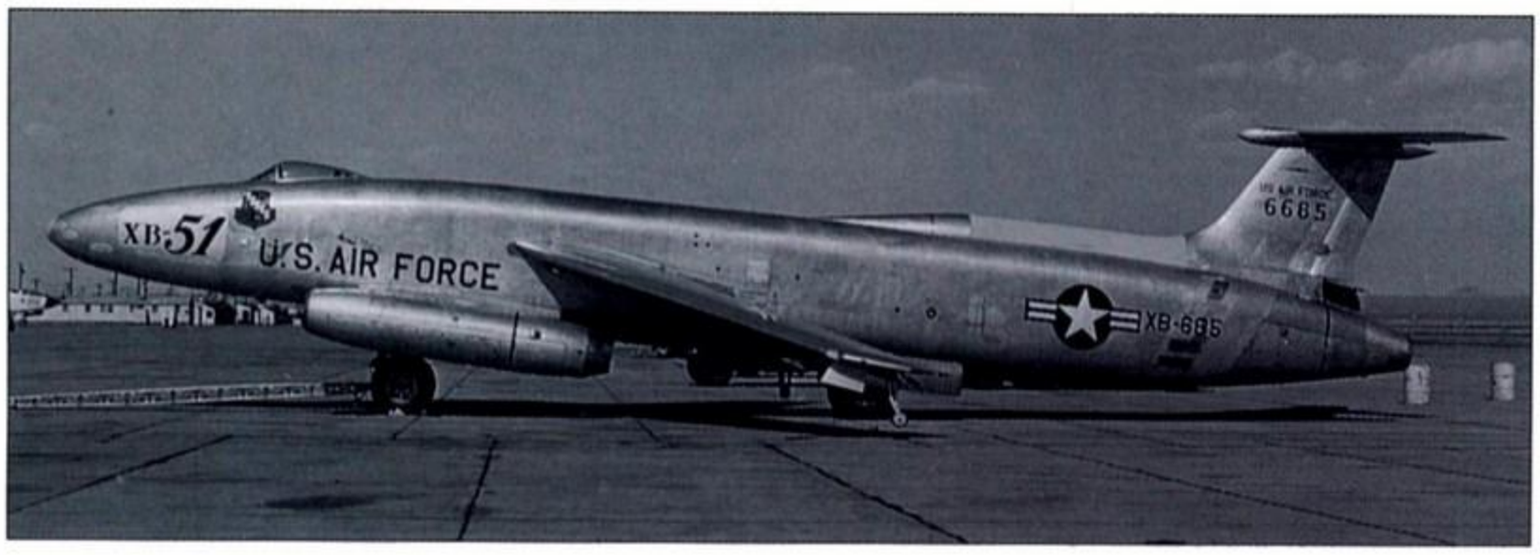
The selection of the Canberra did not immediately mark the demise of the XB-51 programme. An official announcement of the Canberra decision, issued by the Department of Defense on 6 March 1951, noted that "Martin is continuing to develop its own light jet

The XB-51s are seen here on the ramp at Glenn L. Martin Field. Both were lost in fatal accidents, 46-685 on 25 March 1956, when Major James Rudolph, USAF and his crew chief were killed in a take-off accident.

An Industry of Prototypes

Left: Both aircraft (6685 in the foreground) pose on the flight line at Glenn L. Martin Field, 6 April 1950. Note the Martin 2-0-2 transport and a company chase aircraft – RF-80A 44-85042 – in the background. The differing positions of the pitot tube and 'Martin XB-51' legend on the two aircraft may also be discerned.

Right: The XB-51 was a more graceful machine in the air than on the ground. This is 46-685.



Left: This photograph, taken at Edwards AFB, shows 6685 towards the end of its short career, with 'U. S. AIR FORCE' titles, an AFFTC badge and an unusual buzz number behind the 'star and bar'. Note the open drag 'chute door.

bomber, the XB-51, and the Air Force has authorised the company to prepare one of the two experimental models as a production prototype." In a 12 March report of a press conference held by Secretary of the Air Force Thomas K. Finletter, *Aviation Week* stated: "Finletter also disclosed that the Air Force had decided to buy English Electric's Canberra light jet bomber, and that it would be built by Glenn L. Martin Co., Baltimore. This does not mean, he emphasised, that we are shelving the Martin XB-51. It is still undergoing accelerated testing and is being continued as a development programme."

Despite being rejected as a night intruder, the XB-51 remained in contention for procurement as a replacement for the B-26 in the daylight reconnaissance and bombing roles. Aware that the aircraft capable of fulfilling the USAF's aspirations for such an aircraft – as embodied in the Weapon System 302A requirement – was several years from entering production, the USAF sought an interim solution, once again favouring 'off the shelf' technology. Accordingly, on 14 June 1951 the Air Force set in train the selection process for an aircraft to meet its Experimental Light Tactical Bomber/ Reconnaissance Bomber (RBL-X) requirement.

Aircraft considered and rejected for the requirement included the Martin-produced Canberra, the B-45 Tornado and the Vickers Valiant. The USAF's Air Research and Development Command advocated using two aircraft to meet Tactical Air Command's needs: the B-47 for high-altitude bombing, combined with the XB-51 for close air support missions. However, the USAF Aircraft and Weapons Board tentatively selected a design then under development for the US Navy on 29 November 1951: the Douglas XA3D. This decision was endorsed by the Air Material Command on 12 January 1952. Following a protracted development period, the first of some 294 aircraft derived from the XA3D – the Douglas B- and RB-66 Destroyer – entered service with the 363rd Tactical Reconnaissance Wing at Shaw Air Force Base, South Carolina, in January 1956.

Skywarrior derivative

The selection of a land-based (and eventually much-modified) version of the Douglas Skywarrior marked the demise of the XB-51. Production of the aircraft was cancelled in November 1951 – ironically, prior to either of the prototypes being formally accepted by the USAF. Due to ongoing contractor tests on the first prototype, the second XB-51 (46-686) became the first to officially enter the USAF inventory, on 8 December 1951. Edwards AFB took this aircraft on charge on 14 December for high-speed bomb delivery tests, making its first flight from that base on 17 December.

On 22 January 1952, the first prototype also joined the USAF. However, its service career was temporarily curtailed on 28 February of that year when it was damaged in an undershoot landing at Wright-Patterson AFB.

***William Holden ('Major Lincoln Bond', right) and co-star Lloyd Nolan ('General William Banner') pose with the 'Gilbert XF-120' (actually XB-51 46-685) during filming of* Toward the Unknown.**

Further misfortune struck the XB-51 programme less than three months later, on 9 May 1952: during a test flight at Edwards, 46-686 disintegrated in mid-air. Tragically, the sole occupant of the aircraft – Major Neil H. Lathrop, USAF, then head of the flight test branch at Edwards – was killed.

Despite the loss of the second prototype, such was the value of the XB-51 as a bomb delivery testbed that the USAF placed a $381,439 contract with Martin for the repair of 46-685. Following its return to airworthy condition, the last XB-51 returned to Edwards from Wright-Patterson on 28 February 1953, and between 1 March 1953 and 1 March 1954 it was used for a further series of bomb release trials; the project pilot for these tests was then-Major Charles E. 'Chuck' Yeager, USAF. During this period, the XB-51 also embarked on a brief Hollywood career, appearing as the 'Gilbert XF-120 fighter' alongside William Holden in the Warner Brothers movie Toward the Unknown. Sadly, the career of 46-685 was halted by yet another accident, the aircraft being destroyed when attempting to take off from Biggs Field, El Paso, Texas while en route from Edwards to Eglin AFB in Florida on 25 March 1956.

2 October 1951: XB-51 6686 meets the aircraft that the USAF ordered in its stead – the English Electric Canberra. WD940 was one of two pattern aircraft (a B.Mk 2, later reserialled 51-17352) supplied to Martin for use in the B-57 engineering programme.

Although the Martin XB-51 was never to enter production, it did leave an enduring legacy in the influence it exerted on the design of aircraft and missiles subsequently used by the USAF and by overseas air arms. Several of the innovations introduced by the XB-51 were not abandoned with the cancellation of the aircraft; notably, Martin adapted the XB-51's rotary bomb bay for the Canberras built under licence by the company as the Martin B-57, and this feature also influenced contemporary foreign designs. Trials conducted by the two XB-51s during their brief careers as test aircraft also materially contributed to the development of US weapons delivery systems.

Missile legacy

Moreover, two Martin-built missiles – the Matador and Mace – echoed a number of aerodynamic features of the XB-51. Indeed, the early history of the Martin B-61 (later, TM-61) Matador cruise missile paralleled that of the XB-51. A development contract for a 'pilotless bomber' with a range of 500 miles (805 km) designed to USAAF project MX-771A was issued to Martin in March 1946 and the first missile was launched at White Sands Missile Range on 20 January 1949. The Matador shared the swept wing and T-tail of the XB-51; the early XB-61 test missiles were also of mid-wing configuration, although this was changed to a high-wing layout prior to production. The TM-76 Mace was a development of the Matador, and carried forward the basic layout of the earlier missile. **Clive Richards**

Specification

Martin XB-51

Powerplant: three General Electric J47-GE-3 or -17 turbojets with a 5,820-lb (25.89-kN) thrust take-off rating (with water-alcohol injection), plus four RATO bottles rated at 1,000 lb (4.45 kN) thrust, fitted as necessary

Performance: maximum speed 645 mph (1038 km/h) at sea level, 598 mph (962 km/h) at altitude at maximum take-off weight; cruising speed 538 mph (866 km/h); take-off roll 4,340 ft (1323 m)/5,965 ft (1818 m) at maximum take-off weight; initial climb rate 5,100 ft/min (1554 m/min); service ceiling 41,400 ft (12619 m); combat radius up to 595 miles (958 km); landing roll 2,355 ft (719 m)

Weights: empty 29,584 lb (13419 kg); combat (basic attack mission) 41,457 lb (18804 kg); maximum take-off 62,452 lb (28328 kg); maximum landing 57,067 lb (25885 kg)

Dimensions: span 53 ft 1¼ in (16.19 m); length 85 ft 1¼ in (25.94 m); height 17 ft 3 in (5.26 m); wing area 548 sq ft (50.91 m²)

This was the typical SARTF team of later years, one of two HH-53Cs from the 40th ARRS at Nakhon Phanom leading a pair of A-1s from the 1st SOS. The photograph was taken in October 1972, shortly before the A-1 was retired on 7 November. Note the HH-53's open rear ramp, complete with Minigun.

"That others may live"

USAF Search & Rescue

Part Two: 1958-1975 – The war in Southeast Asia

Conflict in Indo-China brought the need for combat search and rescue capability into sharp relief once more. By default, the CIA's airline, Air America, undertook the first SAR missions, but as US forces were committed in numbers and the war intensified, the need for a dedicated SAR force grew. By 1975, the USAF's Air Rescue Service was a well-trained, well-equipped organisation.

The evolution of the co-ordinated mission force of air rescue began during the Korean War when F-51D Mustang fighter-bombers were assigned as part of any rescue attempts taking place within the boundaries of North Korea. The F-51Ds, armed with rockets, bombs and machine-guns, would suppress any enemy activity that might interfere with the successful rescue of a United Nations crewman.

With the peace – or more precisely, the armistice – in Korea, there came the usual reduction in forces and changes in tactics. Tactics developed during the Korean War were rapidly wiped from the minds of the generals in charge. All the problems involved in combat rescues during the Korean War, and the tactical co-ordination involved in the successful rescue attempts that took place, were set aside. The 'new' Air Force was set on improving the image of the modern all-jet Air Force, and thoughts of rescue support aircraft and tactics was merely ignored. There was no need for a combat rescue tactics manual because there was no combat.

Eventually, in 1956, the problem of combat rescue was again addressed. On 28 November 1956, a Joint Chiefs of Staff memorandum called for a study that would standardise rescue procedures on a global basis – not only for the Air Force, but for all services anywhere in the world. The reason for the study was that the new jet aircraft were now operating in areas that overlapped the many command structures from all the services. If an Air Force jet fighter was operating in its assigned zone of operations, it could conceivably be hit and continue on into a Navy zone of operation where the rescue attempt would be made.

Inter-service differences

Problems arose: Air Force personnel and aircraft were trained, equipped, and operated under Air Force operational controls; Navy, Marine, and Army operational equipment and rules could be – and often were – very different from those in the Air Force. Not only were the intra-service activities different, but even the inter-service activities were often different from one area to another. For instance, operational rules and equipment for the European theatre were quite different from those used in the Pacific or in North America. On 1 May 1957, the Air Rescue Service put forth its recommendations for standardised search and rescue procedures. Both the US Army and Navy concurred. Standardised global search and rescue operations became a reality – but not overnight.

It was not until 18 March 1959 that the Air Force Air Rescue Service was officially reorganised to be able to put forth this new global effort. As part of the reorganisation, the structure of the Air Rescue Service was changed dramatically. The 17 squadrons that made up the operational arm of the Air Rescue Service were placed under the operational control of three detachments located at three Recovery Operation Centers, or ROCs. Detachment One was in the Pacific at Hickam AFB, Hawaii; Detachment Two was at Orlando AFB, Florida, in charge of all activities within North America; and Detachment Three was in Europe.

The primary aircraft remained the Grumman SA-16A Albatross amphibian, with support by Sikorsky SH-19 Chickasaw, Piasecki SH-21 Shawnee, Douglas SC-54 Rescuemaster and Boeing SC-97 Stratofreighter aircraft. None of these fixed- or rotary-winged aircraft, however, was entirely acceptable for the mission, but they were the only types available at the time; the times and equipment were changing so rapidly that some ideas were obsolete even before they went to prototype stage.

One of the more innovative ideas was the

An Air America Sikorsky UH-34 (serialled H-15) is seen with rotors turning on the ramp at Bon Xon, Laos, in 1962. The H-34 was the primary rescue helicopter in Southeast Asia well into 1965. This was largely due to it being the only type available, but it also had enough range to reach northern Laos.

Left: A North American T-28D of the Royal Laotian Air Force is seen on the ramp at Udorn in 1966. The RLAF Trojans (with US pilots) were the only fighters available for ResCAP missions until A-1s arrived in mid-1964.

'mother-daughter' concept. Similar to the parasite fighter programme developed for Strategic Air Command, the 'mother' was to be a C-130 Hercules aircraft, which would carry under a wing the small rescue aircraft, i.e., the 'daughter'. Bell Aircraft Company designed the D-190 mid-wing rescue aircraft around a new ducted fan engine design. Unlike the XF-85 Goblin and RF-84K Thunderflash 'parasite fighter' programmes, which actually became operational using SAC RB-36 heavy bomber aircraft, the 'mother-daughter' programme never went beyond the mock-up stage.

In 1960, both the structure and mission of the Air Rescue Service were dramatically changed again, not for the better. On 18 March 1960, the Joint Chiefs cut the authorised strength of the Air Rescue Service from 17 squadrons to an astounding three. While the strength was being drastically reduced, the mission was being expanded to include support of all manned and unmanned space flights. Also included was the planning of evacuation of military aircraft and personnel that might be in the path of a hurricane or typhoon, and the implementation of a Local Base Rescue (LBR) mission, i.e., a rescue service for both military personnel and civilians within the vicinity of any base. On 18 June 1961, with an incoming President John Kennedy supporting the military in many ways, the Joint Chiefs raised the authorised strength from three squadrons to 10 squadrons.

While these different mission requirements were being developed and implemented, operational rescues kept the ARS in the headlines. In July 1960, Soviet MiG fighters shot down an RB-47 Stratojet over the Barents Sea; although the men of the ARS made a valiant effort in the face of the MiG threat, no survivors were recovered. On 14 July, three SA-16 Albatross aircraft from the 31st Air Rescue Squadron plucked 27 survivors of a DC-7 crash from the Pacific Ocean near the Philippines. On 23 April 1962, Detachment 36 rescued 78 people from a flood that ravaged central Mexico. On 24 May 1962, Astronaut Scott Carpenter circled the globe three times before splashing down in the Pacific – 250 miles (400 km) off target. Air Force S/Sgt Ray McClure and A/1c John Heitsch jumped from an SC-54D Rescuemaster and attached a flotation 'collar' to the capsule. All three men and the capsule were recovered by Navy helicopters from the USS *Intrepid*. Later that year, large numbers of Air Rescue personnel deployed to bases in Florida in support of the blockade of Cuba during the October Cuban Missile Crisis.

In August 1960, the United States and the Soviet Union started down the long road that eventually led to the Vietnam War. A civil war in Laos raged out of control between Communist Pathet Lao forces (supported by the Communist Chinese, Soviet Union and North Vietnam) and the Royal Laotian government, which was supported by the United States. Although the Soviets denied any involvement in the civil war, on 16 December 1960 Colonel Butler Toland, the American air attaché to Laos, photographed a Soviet Il-14 transport aircraft dropping supplies to Pathet Lao troops. Seven days later, Toland's unarmed VC-47 transport was hit by Pathet Lao anti-aircraft fire while on a reconnaissance flight over the Plain of Jars, wounding Toland's radio operator. They were the first US Air Force aircraft and personnel to be hit by hostile fire in the war in Southeast Asia.

On 23 March 1961, as President Kennedy was making a speech about Communist aggression in Southeast Asia, Pathet Lao AA fire took the wing off an SC-47 reconnaissance aircraft. The aircraft crashed into the Laotian jungle and the eight-man crew was listed as missing in action. The Laotian war had suddenly escalated to a new level. However, even in light of the shoot-down of the SC-47, Air Force rescue capabilities in the area remained at a standstill. The 13th Air Force did have a search and rescue mission for the area – but had no aircraft to conduct the mission.

Air America's secondary role

The only aircraft available were those being flown by Air America, i.e., the CIA airline. In mid-March 1961, 16 Sikorsky H-34 Choctaw helicopters were provided to Air America for use as transport vehicles, hauling men and supplies throughout Laos, with the additional task of SAR throughout Southeast Asia. Operating from the recently reopened strip at Udorn Thani, Thailand, the Air America H-34s could range to the Plain of Jars in northern Laos, as well as into South Vietnam and Cambodia, should the need arise. Air America had the only rescue helicopter mission

Nakhon Phanom Royal Thai Air Base, known also as NKP or 'Naked Fanny', is seen here with its 'Jolly Green' helicopter detachment right in the middle of the ramp. NKP was the home of the SARTF team of SANDY A-1s and JOLLY GREEN H-3s, the types perhaps most associated with SAR operations in Vietnam.

Search and rescue courtesy of the CIA

This Air America H-34 shares the ramp at Vientiane, Laos, with a Bell Model 204. The Bell replaced the H-34, offering greater transit speed and longer reach.

This was the first large-scale mission against targets in Laos. Until this mission, the policy had been for a maximum of four combat aircraft over Laos at any given time. The strike force on this day, 13 January 1965, consisted of 16 F-105D Thunderchiefs, eight F-100D Super Sabres as MiGCAP and flak suppression, and a pair of RF-101C Voodoo reconnaissance aircraft to take the pre- and post-strike photos. The target was the highway bridge at Ban Ban, Laos.

I was on my third pass against the bridge, guiding an AGM-12 Bullpup missile, when the aircraft [an F-105D] took a hit from a 37-mm or 57-mm anti-aircraft gun in the fuel cell just aft of the cockpit. I immediately jettisoned all remaining stores, lit the 'burner and headed south. About four miles from the target area, the flight controls failed, causing the aircraft to make a sudden pitch-up.

Excessive *g* caused me to black out, and when I regained consciousness, I pulled the ejection handles. The ejection seat was of the old type, and it really gave me a kick in the rear. I separated from the seat and started tumbling end over end. When I got the tumbling stopped, I got a chance to look up at the open 'chute - or rather, partially open. The 'chute risers were all twisted. Observing that my 'chute was only about a quarter open, I shook the risers real hard and it blossomed. I then watched my flaming Thunderchief spin to the ground, crash and explode.

I was still over a 1,000 ft above the ground when I heard what sounded like rifle fire. Moments later, I found myself hanging in a tree. I released the 'chute harness and dropped to the jungle floor. The rifle shots that I'd heard on the way down continued to dog me, and a number of them passed through the heavy foliage of the nearby jungle. I now realised that the 'rifle shots' I was hearing were actually some of the rounds of 20-mm ammunition aboard the Thunderchief I had ejected from. I had landed only a few hundred feet from the aircraft crash site, and the intense fire of the wreckage was cooking off the ammunition.

I heard the noise of jet engines and looked up to see F-105 aircraft circling my position. I removed the emergency radio from my survival gear and attempted to contact the circling 'Thuds' above me. No answer! I tried again as they passed right over me, dipped a wing, then flew out of sight. The other aircraft were at bingo fuel, and had departed for home. Never in my entire life could I recall having such a lonely feeling as I did sitting in the middle of that jungle. I knew I had to shake that feeling, work my way to the best possible position, and wait for a pick-up.

I worked my way out of the jungle and into a large valley. Wanting to position myself on high ground, I decided to climb the slope across the valley to the top of a nearby ridge. The elephant grass that covered the slope made it like walking on ice. I made it about halfway up and had to stop. I was exhausted. I had to relax and calm myself and get ready for the rest of the walk to the top.

Suddenly, I heard the faint sound of aircraft engines. I called on the emergency radio and received an immediate response. The pilot informed me that he was a C-123 and that he was with Air America. Air America was the CIA-operated airline flying supplies all over Southeast Asia, supporting anyone that was anti-Communist. They also were the best rescue chance that we fighter jocks had going at this time in the war. As the engine noise became louder, I started to direct him to my position. He passed right over me, but now I could not see him as the sky had become heavy with cloud cover. He turned back toward my position and started another run. Closer and closer he came. When I felt he was directly over me, even though I could not see him, I called him and told him. A few seconds later I saw the big twin-engined transport descend out of the clouds. He located my position and set up an orbit about a mile away so as not to draw the 'bad guys' to my position.

The Air America pilot advised me that he was in contact with a helicopter, also Air America, and for me to remain where I was. As I waited for the helicopter to arrive, every minute dragged. It seemed like every minute was taking an hour. Finally, I heard the C-123 driver giving directions to the helicopter as to my position. I then saw the chopper, an H-34, come over the ridge and drop down into the valley below me. As he came up the valley toward me, he took some small arms fire from the nearby jungle, but did not sustain any major damage.

The chopper approached me, lowered the sling, then slowly moved up the slope to get into position for my pick-up. His blades started hitting the elephant grass that was growing on the slope all around me. Elephant grass grows quite high in Southeast Asia, and is very sharp when being blown around by helicopter rotors. The sling was only a few feet from where I lay, but the helicopter was forced to back off when he saw his blades hitting the grass.

The C-123 pilot got on the radio and told me to stay put. The chopper would return, extend the sling a little further, and drag it past me. I would have to grab it as it went by, and hold on as the helicopter started to pull up. It was the only way the helicopter pilot could make the pick-up on such a steep slope. I watched as the sling came directly at me, grabbed it, and hung on for dear life. As I was hoisted into the helicopter, the longest 50 minutes of my life came to an end.

The Air America helicopter flew me to a Lima Site somewhere in Laos. After about an hour at the Lima Site, a single-engined, turboprop Pilatus Turbo-Porter arrived and took me to Udorn for debriefing. I learned from the Air America guys that our mission had been delayed twice due to bad weather. That meant the Air America rescue choppers had prematurely been released from their rescue mission. My guy had been on a supply run when he heard my 'May Day' call. Loaded with personnel (he did not say what kind), he landed in an open field and told them all to get out. He and his winch operator then headed north in my direction.

It had really been my lucky day.

Lieutenant Colonel Albert C. Vollmer
13 January 1965

Air America, the CIA 'airline', had a fleet of ex-US Air Force cargo aircraft to transport men and supplies throughout the various areas of conflict in Southeast Asia. Between 1962 and 1966 these aircraft also operated as airborne command posts for any rescue effort. This is a Douglas C-47 (with Nationalist Chinese civil registration), seen at Da Nang.

anywhere in the region. In this manner, no US official military units were committed to the growing conflict.

Reconnaissance was the primary concern in the Laotian conflict. Declining to commit Air Force RF-101C Voodoo reconnaissance fighters, a move that would indicate an open US commitment to the conflict, Kennedy's advisors suggested that Philippine Air Force RT-33s be repainted with Royal Laotian Air Force markings, but with US Air Force pilots. With that, a search and rescue mission became a vital concern. The North Vietnamese were moving more heavy-calibre, radar-directed anti-aircraft artillery into Laos in support of the Pathet Lao, increasing the possibility that US personnel would be lost. On 16 April 1961, PACAF committed six F-100Ds from the 510th TFS to the air defence of the area, further increasing the probability.

By late July 1962, the war in Laos was losing some steam after President Kennedy and Chairman Khruschchev had brokered a delicate truce. No sooner had the Laotian situation cooled, though, than the civil war in neighbouring South Vietnam began to heat up, putting still more US men and equipment in harm's way. On 11 October 1961, Kennedy authorised Operation Farm Gate, which sent North American AT-28 fighter-bombers, more SC-47s, and Douglas RB-26 Invader light reconnaissance bombers to bases in South Vietnam. From 16 December 1962, combat operations were flown with US Air Force crews, plus a token South Vietnamese to stay within the guidelines of the 1954 UN accords.

By the end of January 1963, Farm Gate aircraft had flown 229 combat sorties – still without an adequate search and rescue capability in the event of an aircraft going down. The Air Rescue Service did not even have a true combat SAR operating procedure, for all the planning since the end of the Korean War had been toward a global rescue mission in peacetime. An additional concern was that an organised search and rescue effort in place anywhere in Southeast Asia would have been tantamount to an admission that US personnel were already committed to the fighting.

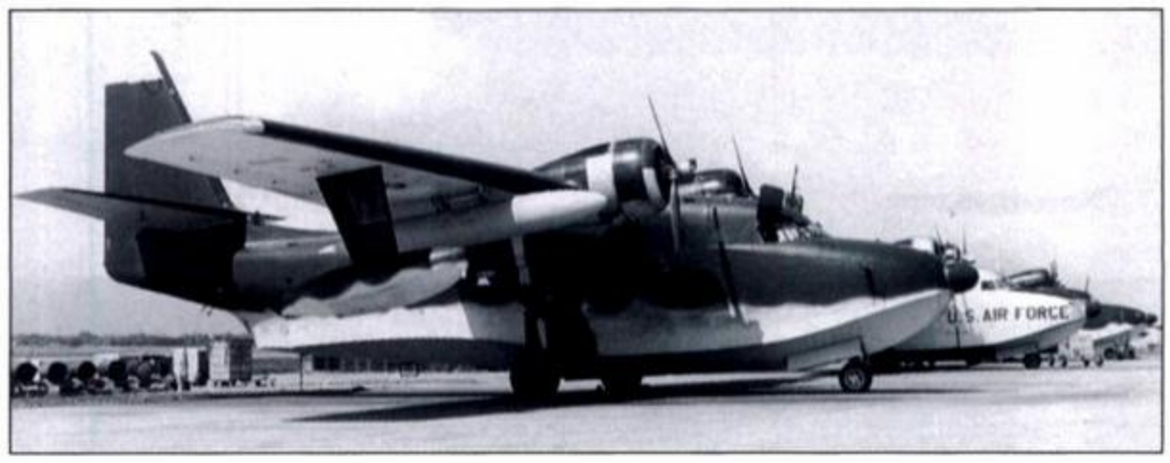
However, there was a SAR organisation in place at Tan Son Nhut from December 1961. The Tan Son Nhut Search and Rescue Center was a bare bones effort, to put it mildly. The arriving 2nd Air Division personnel found themselves not only without any aircraft, but also with empty operations huts – no telephones, no radios, no desks, not even chairs. After obtaining some badly needed communications equipment, the 2nd AD search and rescue people began contacting various US Army commanders throughout the four military regions in South Vietnam – I, II, III and IV Corps – quickly obtaining the use of US Army helicopters for any search and rescue mission.

First USAF losses

The Air Force suffered its first losses in early 1962, when a Ranch Hand C-123 defoliation aircraft crashed at Tan Son Nhut on 2 February, with all hands lost. On 11 February a Farm Gate SC-47 went down in the mountains west of Saigon. The Tan Son Nhut SAR Center sent an Army H-21 helicopter with South Vietnamese Army (ARVN) troops to the crash site. Again, no one aboard the SC-47 leaflet aircraft survived. The mission was the first true SAR sortie conducted inside South Vietnam. On 1 April 1962, the Tan Son Nhut SAR Center was officially recognised as Detachment 3, Pacific Rescue Center. For better or worse, the US Air Force was now 'officially' involved in the Vietnam War.

Det 3 still had no aircraft of its own, relying on US Army and Marine helicopters for any rescue attempts within the borders of South Vietnam. Air America was still the only rescue 'unit' for out-country activities. The first major incident to try the search and rescue procedures in place in South Vietnam occurred on 8 October 1963. A pair of Farm Gate AT-28s attacking targets in the mountains west of Da Nang came under attack themselves from enemy anti-aircraft fire, and one of the aircraft crashed in the jungle.

Major Alan Saunders, Commander of Det 3, marshalled his forces for an attempted rescue of the downed crew. He ordered a pair of Marine H-34s with ARVN troops to proceed to the crash site, neither of which returned. The following morning, several more Marine H-34s air-lifted two companies of ARVN infantry to the area, known as VC Valley. As the H-34s touched down and the ARVN troops jumped from the helicopters, they were immediately



Above: Seen in December 1966, a Grumman HU-16B Albatross from Det 5, 37th ARRS shares the ramp at Da Nang with its replacement, the Lockheed HC-130. The plates on the aft fuselage above the entry ladder were attachment racks for the Jet-Assisted Take-Off (JATO) bottles.

Above: Several HU-16Bs from the 37th ARRS line the ramp at Da Nang in 1966. In late 1965 the USAF began to add the dark blue/light grey camouflage.

Left: A 33rd ARS flight crew undergoes inspection in 1967 at their Naha AB, Okinawa, base. The 33rd supplied several of the HU-16Bs and crews for Southeast Asia operations.

Kaman's Huskie, with its unusual 'egg-beater' rotors, was primarily used as a base rescue and firefighting helicopter, but it was pressed into service on short-range rescues. This is an HH-43B, seen carrying a fire suppression kit near Da Nang in 1967.

First on the scene, an HH-43F hovers over an A-1E which made a wheels-up landing at Da Nang in May 1967, slinging the fire extinguisher beneath it. The Huskie had small skis on each wheel to increase its footprint for operations from soft surfaces. In this instance the pilot was uninjured and the Skyraider returned to flying status soon after the accident.

engaged by heavy machine-gun fire. However, Major Saunders had some air support for this attempt. Farm Gate AT-28s and RB-26s, plus Vietnamese Air Force A-1 Skyraiders, bombed and strafed the Viet Cong positions until the landing zone was secure.

The ARVN troops then made their way to the area of the two crashed Marine H-34s from the previous day, where they found that 10 of the 12 personnel who had been aboard were dead, and the other two were missing. On 11 October, Major Saunders went back to the area on one final attempt to locate the downed AT-28 and its crew. After finding the aircraft, which had crashed into a creek and was partially submerged, Major Saunders went back to the LZ for the pick-up. As the Det 3 team was about to be airlifted from the jungle, Viet Cong machine-gun fire shot out the engine of the H-34. An Army Huey and two Farm Gate AT-28s quickly silenced the VC guns and Major Saunders's crew was picked up by a second Marine H-34.

Three days later, Major Saunders again returned to the crash site, this time with an escort of US Army Green Berets and ARVN Rangers. Saunders scoured the area for three

PEDRO 96 downed, May 1967

Our mission on this day was to extract some wounded Marines who had been involved in a firefight with the VC about 12 miles southwest of Da Nang. My crew for the day was First Lieutenant Al Jacox as co-pilot, with S/Sergeant John Tobey and T/Sergeant Phil Resos as PJs. We arrived over the scene of the battle, and hovered between 150 and 200 ft above the jungle floor. There were four wounded Marines down there and we lowered the penetrator and began hauling them in. Three of the Marines were aboard and we had the fourth one (and Sergeant Tobey) on the cable about 40 ft above the ground, when the chopper suddenly shuddered.

A VC sniper had raked the HH-43 engine with machine-gun fire and we were about to fall out of the air. I yelled at Sergeant Resos "Get them back down on the ground!", and he started to lower the wounded Marine and Sergeant Tobey back to the jungle floor. PEDRO 96 started to nose forward and lose altitude. As we settled into the tops of the trees, I threw the controls hard to the left in an attempt to keep the falling helicopter from crushing the two men on the ground. As we fell through the trees, the rotor blades disintegrated, sending pieces in every direction. Sergeant Resos was still hanging part way out of the back of the helicopter as we dropped through the trees. The chopper hit the ground with a thunk, slamming Sergeant Resos into the inside of the helicopter. His arm got caught between the sliding armour plate door and the frame, nearly severing it. My legs and feet got tangled up in the rudder pedals, and I had multiple breaks in my ankle and foot, plus a broken lower leg bone.

As we extracted ourselves from what remained of PEDRO 96, the remainder of the Marine patrol whom we had come to save rushed back and helped us get free of the twisted remains of the helicopter. Then we set up a defensive perimeter, since the 'black pyjama gang' was still out there somewhere.

About an hour later, a 'Jolly Green' helicopter out of Da Nang came over and started to make a pick-up. We found out later that the 'Jolly Green' had been training on inflight refuelling with an HC-130P over the South China Sea. By now, the VC had set up a neat little trap, using us as bait. Heavy machine-gun fire raked the 'Jolly Green', wounding T/Sergeant Ray Weddell in the leg. The 'Jolly Green' was forced to pull up and withdraw back to Da Nang to take care of Sergeant Weddell. He later lost that leg.

Soon, a Marine CH-46 arrived on the scene. It, too, was raked by heavy machine-gun fire and had to withdraw. One of the Marine door gunners was hit in the neck and they rushed him back to Da Nang. By this time, it was starting to get dark, and there was now a cloud deck over our position. Darkness would preclude any further attempts at a rescue. We would have to wait for morning.

The night was far from boring. Between treating patients, including myself, and keeping a wary eye out for the VC which were trying to get to us, plus the incessant Marine artillery that was keeping 'Charlie' off of us, it was a very sleepless night. Sergeant Resos manned one of the 50s all night long, even though he was in constant pain.

Early on the morning of the 9th, another Marine CH-46 came in. The VC poured machine-gun fire at the Marine helicopter. But they had an escort; as soon as the VC opened up, a flight of Marine F-8 Crusaders from Da Nang came in and pounded them with 500- and 750-lb bombs and rockets. The Marine chopper pilot kept the CH-46 at treetop level and lowered the hoist.

The wounded Marines were the first to take the cable ride. Then it was my turn. The VC had come out of their holes again and were firing at us as we rode the cable back up to the chopper. The CH-46 was hit several times. Two of the Marine crew were wounded. Sergeant Resos manned the 50 and helped suppress the enemy fire as I rode the cable. As I came up through the jungle canopy, several enemy rounds were very close, some impacting right above me in the bottom of the CH-46.

Those Marine pilots, although taking a lot of fire, kept a steady hover over the hole in the jungle canopy. Finally, as we were attempting to bring the rest of the Marine patrol up, the hoist motor burned out, and we were forced to bring the cable in by hand. As we departed the area, I looked out the back and saw a long trail of vapour – fuel vapour. Evidently, the VC had hit the fuel tanks.

We weren't too far from Da Nang and the Marine base at Marble Mountain. We were taken to the Marine hospital at Marble Mountain. I had previously delivered many casualties to this very same hospital door. As they carried me in on a stretcher, one of the attending Marine corpsmen looked at me and said, "What the hell are you doing here? I've seen you flying one of the choppers bringing in wounded. Now you are one!"

Major John Hoye
Commander, Detachment 7, 38th ARRS
Da Nang

1st Lt Lynn F. Gormley receives a briefing on the forest penetrator hoist system of the HH-43 from a Det 14, 38th ARRS captain at Tan Son Nhut AB. The penetrator became the most efficient way of retrieving aircrew from beneath triple-canopy jungle.

A pararescueman (otherwise known as a parajumper or PJ) is lowered from a 38th ARRS HH-43F Huskie on the jungle penetrator during a rescue near Bien Hoa in January 1966. The HH-43F was the first helicopter in-theatre to be equipped with this valuable tool.

Right: An HH-43B 'Grey Lady' hovers near base firefighters during a practice 'burn' at Da Nang in 1965. The Huskie used its rotor downwash to blow smoke and heat away from the ground team.

Below: This HH-43B was from Det 5, 38th ARRS, and is seen during a training mission from Ubon. The HH-43B was replaced in the base rescue mission by first the armoured HH-43F and, from 1973, the Bell HH-1H.

more days, looking for survivors or bodies – with negative results. The loss of the VNAF AT-28, with its American pilot and VNAF crew member, and the subsequent search and rescue attempts, had cost the lives of three Americans, at least 20 ARVN troops, and three H-34 helicopters, not counting the significant damage suffered by several of the ResCAP aircraft.

Vietnam was not Korea. In Korea, an air rescue H-19 could proceed into North Korea with a ResCAP of four F-51Ds, and have a reasonably good chance of success. The jungles of Southeast Asia, and the concerted efforts of the North Vietnamese (NVA) and Viet Cong to capture any pilot who went down in the area, made the air rescue mission a totally different operation than in Korea. The NVA and VC were determined to stop all rescue attempts, or at least to make the cost of the rescue very expensive in both lives and equipment; the US forces were equally determined that they would pull a downed airman from the clutches of the Communists.

By early 1964, Major Saunders's Det 3 team had defined the rescue mission in Southeast Asia, and pin-pointed several areas of concern. One was the training of personnel in actions to take if their aircraft or helicopter crashed, especially in a water landing. Several Army UH-1 Huey crews had been lost when their UH-1 had come down in one of the many wetland areas of South Vietnam; the crews could not get out of the aircraft in time and many drowned trying to escape from the cockpit. Major Saunders devised a Huey trainer which simulated a crash landing using the Bien Hoa swimming pool, in which the crews practised getting out of the confined Huey cockpit and into a raft. All Army helicopter personnel had to go through either the course at Bien Hoa or one of several set up at Army helicopter training bases in the United States.

The other major problem for the mission in Southeast Asia was availability of air rescue equipment and aircraft. The primary rescue helicopter at the time was the Kaman HH-43B Huskie, a short-range helicopter used primarily for fire-fighting on the flight line. It could be used for rescue work on or very near the air base, but was almost totally ineffective for even short-range rescues in the Laotian high country, much less the long-range missions that were just starting to become reality.

The Army had UH-1 Hueys and H-21 Shawnees, while the Navy and Marines used the H-34 and the Kaman UH-2 Sea Sprite. Most of these types were usually involved with transport operations, and none was a true rescue type with full capabilities to operate in the jungles of Southeast Asia. The new Sikorsky S-61 (H-3) was becoming available, but all the new aircraft were allocated to the spacecraft recovery programme.

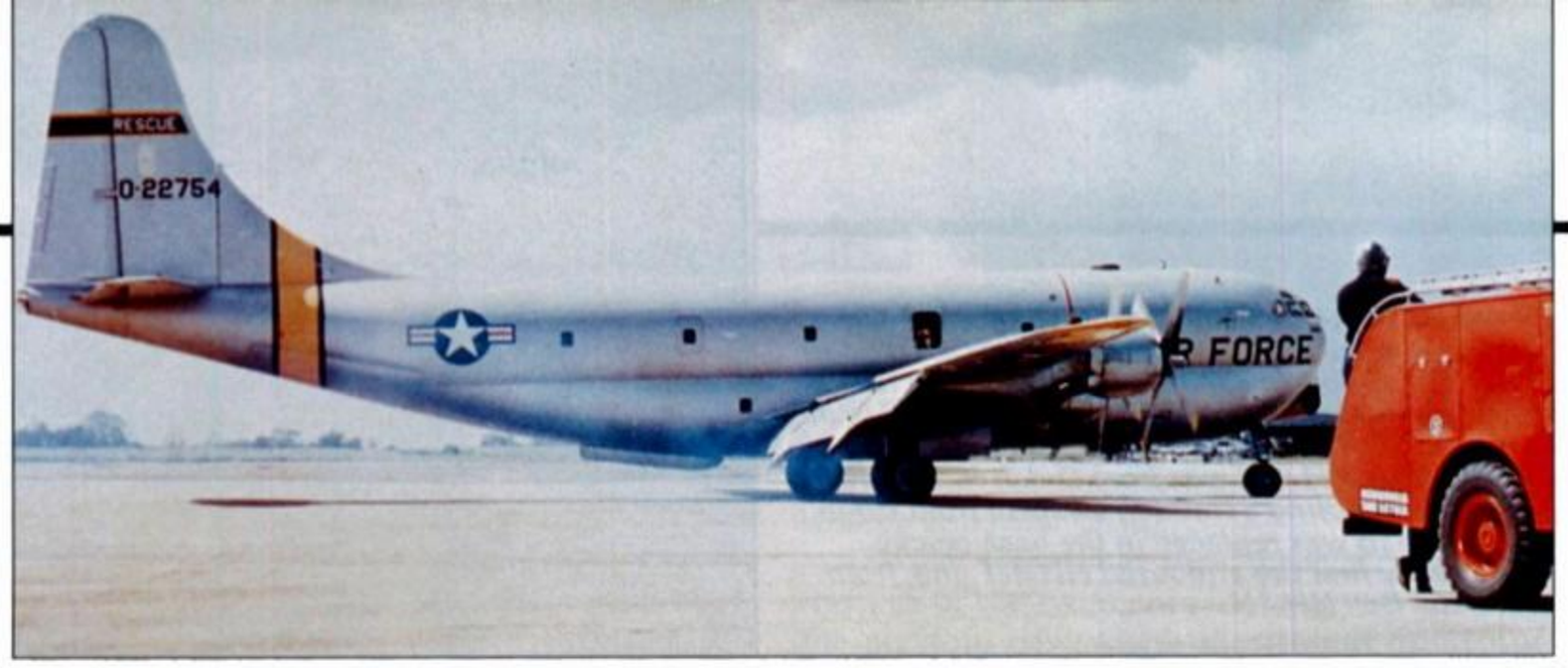
Making do with the Huskie

Until the H-3 became readily available, the Air Rescue Service would have to make do with the Kaman Huskie. Noting some of the problems encountered in Southeast Asia, ARS personnel came up with a modified HH-43B that was better suited for the mission. They added armour plate under the cockpit, a bigger, self-sealing fuel tank, upgraded T53-L-11A engine rated at 1,150 hp (858 kW), gun mounts for self-defence, and a hoist fitted with a weighted cable, called a 'jungle penetrator'. The modified types were designated HH-43F, but they would not be available until the autumn of 1964. The Air Force pulled six more HH-43Bs from non-combat bases, and rushed them to Southeast Asia in March 1964. All long-range, overwater rescues would be handled by the venerable Grumman HU-16 Albatross triphibian and the Boeing HC-97G. In Thailand, the recovery was still being handled by Royal Thai Air Force H-19s and Air America H-34s.

The effort was proving inadequate as the war in Laos started heating up again. Beginning on 16 March 1964, the Pathet Lao Communists launched an all-out attack to take control of the country, with the major assault coming over the Plain of Jars. Almost as soon as the Pathet Lao troops took over an area, the North Vietnamese moved in heavier, radar-directed AAA. The North Vietnamese Army was equipped with large numbers of Soviet 37-mm and 57-mm, rapid-firing anti-aircraft artillery. Each of these guns could fire up to 150 rounds per minute, and strike an aircraft at altitudes up to 15,000 ft (4572 m). In late August 1964, an Able Mable RF-101C reported over 200 rounds of AAA exploding near his aircraft at 10,000 ft (3048 m) while flying over a solid undercast.

The North Vietnamese AAA was very accurate, and they used it to create 'flak traps' around downed US airmen. One of the first examples of a flak trap was seen on 6 June 1964, when a Yankee Team RF-8A Crusader from VFP-63 aboard the USS *Kitty Hawk* was shot down near Ban Ban on the Laotian/North Vietnam border. Navy Lieutenant Charles

A Huskie inspects the wreckage of a B-66, brought down over South Vietnam in April 1966. One can easily imagine the problems encountered while locating and retrieving downed aircrew from this sort of vegetation, which covered much of the warzone.



The Boeing HC-97G was the long-range rescue aircraft that would have replaced the Douglas HC-54D in Southeast Asia and elsewhere, had it been more widely available. Only about 30 were converted (from KC-97s) and served for only a short period, until the arrival of the HC-130.

Klusman ejected from the dying RF-8, but was immediately surrounded by North Vietnamese heavy anti-aircraft batteries.

His location precluded the rescue attempt coming from either an Air Force or Navy helicopter. He was out of range of the HH-43s based in Thailand, and very far from the nearest carrier-launched Sea Sprites. Air America had the only aircraft with sufficient range to reach the downed Navy flier. An Air America U-10 located Lieutenant Klusman and made arrangements for a helicopter pick-up. When the two Air America H-34s arrived on the scene, the NVA opened fire, hitting both helicopters and wounding several members of the crews. Both H-34s made it safely out of the area, and diverted to the nearest Lima Site to make repairs. (Air America had several refuelling areas throughout Laos called 'Lima Sites'.) The next day, two flights of Thai Air Force AT-28s overflew the area but Lieutenant Klusman was nowhere to be found. He had escaped into the jungle and did not resurface again until 1 October, when an Air America H-34 found him.

On 7 June, Navy Commander D. W. Lynn's F-8D Crusader was shot down in the same area as Lieutenant Klusman. Commander Lynn, a VF-111 pilot who had been escorting another VFP-63 RF-8A, successfully ejected from the burning F-8D into the same Laotian jungle that was hiding Lieutenant Klusman. The rescue attempt sent a pair of Air America H-34s with an escort of Water Pump AT-28s. (Water Pump was a programme to train Laotian pilots in the AT-28, but the combat missions usually were flown by US pilots.) The rescuers searched the area but came up with nothing.

Commander Lynn had made a successful ejection, and upon landing had activated his beeper, a small homing transmitter which was part of his ejection equipment; unfortunately, Navy beepers were on a different frequency to Air Force locating devices, and the rescue effort was being conducted in the wrong area. Luckily, the following morning, an Air America C-7 Caribou, which was equipped to monitor the Navy emergency frequency, located Commander Lynn, and an Air America H-34 extracted him from the jungle. This was indicative of the problems commensurate with any rescue attempt during the pre-Tonkin Gulf era.

On 29 May 1964, Major General Joseph Moore asked Pacific Air Force (PACAF) Headquarters for permission to use Air Force rescue units in the Laotian war and, with losses starting to mount, it was reluctantly given. By mid-June, the first Air Force rescue unit was en route to Thailand. A pair of 33rd Air Rescue Squadron (ARS) HH-43Bs deployed from Naha AB, Okinawa to the base located nearest to the Laotian border, Nakhon Phanom, commonly referred to as NKP. Along with the deployment to NKP, a pair of US Marine H-34s was sent to the Marine fire base at Khe Sanh for possible rescue duties into eastern Laos.

HU-16B controller aircraft

To complete the rescue 'team', a pair of 33rd ARS HU-16Bs was sent to Korat to act as airborne controller aircraft for all rescue attempts. At the same time, three 33rd ARS HU-16Bs deployed to Da Nang in the event of a water rescue in the Gulf of Tonkin. By 20 June, the HH-43Bs were operational from NKP but their extremely short range, only 140 miles (225 km), still kept them from making any attempts to the Plain of Jars. Not only did the HH-43Bs not have the needed range, they were standard Huskies with none of the combat equipment found on the HH-43F. By this date, the Air America fleet of helicopters had dropped from 16 H-34s to four, due to combat losses and equipment failures.

Between 2 and 4 August 1964, North Vietnamese Navy torpedo boats attacked the US Navy destroyers *Maddox* and *C. Turner Joy* in the Gulf of Tonkin, effectively beginning the Vietnam War. President Lyndon Johnson rushed additional Air Force and Navy units to Southeast Asia, where they flew the first of thousands of combat sorties against Communist forces in Laos, Cambodia, and North and South Vietnam. With the great influx of fighters and bombers came additional air rescue forces, including Detachment 4, 36th ARS equipped with HH-43Bs. Det 4 was initially based at the newly opened air base at Takhli. In September, the first six HH-43F combat rescue helicopters, nicknamed the 'Pedro', were delivered to Southeast Asia.

The Air Rescue Service now had its aircraft and personnel in place throughout Southeast Asia; not a major effort, but it was a start. Rescue Combat Air Patrol (ResCAP) support would be supplied by Air Force and Navy fighter-bombers, as well as Water Pump AT-28s and Vietnamese Air Force (VNAF) A-1 Skyraiders. Command and control aircraft and tactics were ready. Unfortunately, the actual recovery still would have to rely on the Kaman HH-43B Huskie and HH-43F 'Pedro', and Air America, the drawbacks of which were painfully evident during a SAR effort that began on 18 November 1964.

On that date, North Vietnamese gunners using 37-mm brought down a 613th TFS F-100D flown by Captain W. R. Martin, which crashed near Ben Senphan in central Laos. The SAR forces scrambled into action. Co-ordinating with the Air America Operations Center, one of the 33rd ARS HU-16Bs assumed airborne tactical control for the SAR effort. As the HU-16B located the downed F-100, it called for ResCAP support from Navy A-1s operating nearby. Escorted by the Navy ResCAP Skyraiders, a pair of HH-43Bs from NKP tried – unsuccessfully – to locate the downed Super Sabre pilot. The following day, a second HU-16B controller aircraft saw his parachute atop a small Laotian mountain, called a karst. Air America scrambled a pair of H-34s to the area, one of which lowered a man to the ground. Unfortunately, Captain Martin had not survived the landing.

The total resources used in the effort to save Captain Martin indicate just how great the

The 602nd ACS pioneered the ResCAP mission with its ex-US Navy A-1Es. Normally based at Pleiku (where this aircraft is seen in 1966), the unit sent a detachment to Udorn to operate as part of the first dedicated Search and Rescue Task Force.

Armourers load 500-lb bombs under the wings of a 1st ACS A-1E Skyraider on the PSP ramp at Bien Hoa in 1965. The 1st ACS was primarily a fighter-bomber unit, but was often called upon for ResCAP duties. This aircraft (ex-US Navy A-1E BuNo. 132649) was the one flown by Major Bernard Fisher on the mission which resulted in him being awarded the Medal of Honor.

resolve was of US forces to save one of their own. The SAR effort included three HU-16Bs, two HH-43Bs, four Air America H-34s, 17 F-105 Thunderchiefs, eight F-100 Super Sabres, six Navy A-1s, and four Water Pump AT-28s from Savannakhet. At this point, the search and rescue mission in Southeast Asia needed a lot of improvement.

Things began rapidly changing as the US attack force began its build-up. Shortly after the Tonkin Gulf Incident, the Air Rescue Service began organising, training and equipping new units for Southeast Asia duty. Overall command remained with Det 3, Pacific Air Rescue Center at Tan Son Nhut, with helicopter detachments at Bien Hoa (Det 1) and Da Nang (Det 2). Crews slated for duty in Southeast Asia were sent through a special HH-43 school at Stead AFB, Nevada, where they learned to do things with the Kaman Huskie for which it was never designed. Combat required both aircraft and crews to perform above and beyond. As these crews and their HH-43F 'Pedroes' arrived at Bien Hoa and Da Nang, they were immediately formed into Detachments 4 and 5. The original Det 1 and 2 personnel and aircraft were transferred to Takhli and NKP.

The total helicopter inventory available to air rescue units in Southeast Asia in late 1964 was 13 HH-43B/Fs. The first of the combat-modified HH-43Fs arrived in Southeast Asia in late September 1964, featuring titanium armour plate surrounding the crew compartment and the engine, which now delivered 1,150 hp (858 kW). A new self-sealing 350-US gal (1324-litre) fuel tank increased the combat radius of the F model to 120 miles (193 km). The addition of new radio equipment, including both VHF and FM command radios, allowed the rescue crew to communicate directly with the airborne controller and any ResCAP forces, plus ground troops in the area.

It was the Kaman engineers who came up with an idea that led to the jungle penetrator, a device to extract downed airmen from the dense rain forests of Southeast Asia. Many of the trees in the jungles of Laos, Cambodia and North and South Vietnam were well over 100 ft (30 m) in height. There were vast areas where an airborne crew could not see any type of ground terrain. The penetrator was a 200-ft (61-m) steel cable with a weighted probe that had spring-loaded arms to help it negotiate the jungle canopy. Once on the floor of the jungle, the arms could be extended to form a type of 'seat' for the airman, who climbed aboard the penetrator and was pulled back through the jungle canopy to safety. The penetrator could also be used to lower a pararescueman, known as a parajumper or PJ, through the canopy to assist a wounded or injured airman. Being dragged out through the jungle canopy could prove to be a rough ride, especially if the area was 'hot', with enemy troops firing at the rescue helicopter. It was not uncommon for a pilot to ride the penetrator up through the canopy and then hang in mid-air several hundred feet above the ground, while the helicopter flew several miles to safety, before being hauled into the safe confines of the helicopter.

No matter how many modifications were done to the HH-43 to make it better suited for combat, it was not, and never would be, the rescue helicopter needed in Southeast Asia. Almost a full year after the official beginning of US involvement in the Vietnam War, the air rescue mission still relied on Air America helicopters for long-range rescue attempts in northern Laos or North Vietnam. In June 1965, Air America was recovering downed air crews at a 5:1 ratio compared to their Air Force counterparts.

ResCAP Skyraiders

The JCS, Air Rescue Service Headquarters, and Headquarters at PACAF and 13th AF were working to make even the limited-use HH-43F more successful. They came up with the idea of the Search and Rescue Task Force, or SARTF. A typical task force was be made up of an HU-16B airborne controller aircraft, a rescue helicopter from the nearest base (either Air Force, Navy or Air America) and, for the first time, a dedicated ResCAP flight of fixed-wing, propeller-driven fighter-bomber aircraft, i.e., the Douglas A-1 Skyraider.

The primary controller aircraft initially was the HU-16B, with modifications to its communications equipment. Not only did the HU-16Bs act as airborne controllers, they were also able to physically perform any water rescue attempts, which could be hazardous in the unknown waterways of Southeast Asia. In mid-1965, the HU-16Bs moved from Korat to Udorn to be closer to the action, which, more often than not, was taking place inside North Vietnam.

This 1st ACS A-1E seen at Da Nang in early 1967 exhibits a typical SANDY loadout, having Minigun pods on the inboard pylons with rocket pods and phosphorus bombs on the outer wing pylons.

Seen at Udorn in 1966 while assigned to the 602nd ACS, this A-1E was subsequently lost over Laos on 13 March 1968. The GAU-2B Minigun pod on the inboard pylon could fire at a rate of 6,000 rounds per minute.

Above: One of the original two CH-3Cs pressed into service with the 37th ARRS is seen at Da Nang in 1966. Note the M60 machine-gun in the forward door and the national insignia 'placard'. The latter could be removed when the aircraft was operating in the wrong country.

Left: The Sikorsky CH-3C was primarily a transport helicopter, but was pressed into duty as a rescue helicopter in Southeast Asia. This CH-3C is bringing in supplies to a Special Forces camp in South Vietnam's Central Highlands.

However, the HU-16B with its modified communications equipment was unable to electronically match the complicated forces that were now involved in the air war over North Vietnam. In June 1965, PACAF transferred three SC-54D Rescuemasters, with much more sophisticated communications systems, from bases in Japan and Guam to Udorn to assume the air controller mission. When the SC-54Ds arrived at Udorn, the HU-16Bs were transferred to Da Nang. The SC-54Ds remained at Udorn until they were replaced by HC-130Hs in December 1965.

The escort part of the task force began with continued use of the Water Pump T-28Ds, but they were available only when they were not involved in normal duty assignments, i.e., training of Laotian pilots, and ground support missions against the Pathet Lao. The A-1 Skyraider was the obvious answer to the need for a ResCAP aircraft. It could carry a huge ordnance load, up to 7,000 lb (3175 kg) of bombs, rockets and CBUs. The A-1 was reasonably fast, but slow enough to be able to fly close escort to the helicopter if necessary. Most importantly, it was readily available since the US Navy was phasing it out of active service.

The Air Force recognised that the A-1 was the aircraft it needed for the ResCAP mission, and for the close support mission in South Vietnam. Ironically, the Air Force had rejected the A-1 in the early 1950s due in part to inter-service rivalries and the perceived importance of its image as an all-jet Air Force. On 30 May 1964, the first Air Force A-1Es arrived at Bien Hoa to replace the Farm Gate contingent of AT-28s and RB-26s, but they were not specifically tasked with the ResCAP mission until August 1965. At that time, the 602nd Air Commando Squadron sent a detachment of A-1Es to Udorn as part of the SARTF that was beginning to take shape.

First H-3s at NKP

Finally, in mid-summer 1965, the first helicopter capable of sustained combat operations in the ever-widening war in Southeast Asia arrived – the Sikorsky H-3 Sea King. Arriving at NKP on 6 July 1965, the first two aircraft were modified CH-3C cargo transports. The CH-3C was much faster than the HH-43B or F – 162 mph (260 km/h) compared to 120 mph (193 km/h) in the HH-43 – and had a much greater radius of action, 500 miles (805 km) rather than 250 miles (402 km) in the HH-43. The CH-3C had protective armour plate for the crew, and both aircraft were modified with an electric winch and jungle penetrator. In each of the forward cabin doors was a flexible mount for firing an M60 light machine-gun.

The CH-3Cs were already painted in the tan-and-two-greens tactical camouflage worn by all tactical aircraft from mid-1965, and the Air Force H-3s were affectionately nicknamed 'Jolly Green Giants'. In the war in Southeast Asia, the name was extremely appropriate, for the crews performed gigantic and heroic tasks on a daily basis.

The CH-3C was still not precisely what the Air Rescue Service wanted. The Air Rescue Service team at Orlando AFB, home of the ARS, sat down with Sikorsky engineers to design and develop a helicopter dedicated to the rescue mission. The 'HH-3C' (as it was unofficially designated) differed almost as much from the transport CH-3C as the CH-3C did from the HH-43. Powered by a pair of 1,400-hp (1044-kW) General Electric T58-GE-10 engines, the 'HH-3C' had a top speed in excess of 160 mph (257 km/h). Although the service ceiling was 12,000 ft (3658 m), most combat missions called for cruising at 10,000 ft (3048 m), well away from small arms and light machine-gun fire. When the 'HH-3C' did drop down to hover just above the jungle canopy, the crew was protected by 0.5-in (1.27-cm) thick titanium armour plate. If needed, and it usually was, there were both fixed and flexible

A HH-3E from Det 7, 37th ARRS pulls a downed US pilot from the waters of the South China Sea off the coast of Da Nang in 1967. Air Force SAR units pulled both Air Force and Navy aircrew out of the jungle and and oceans around Vietnam, although the Navy did have a dedicated SAR mission for at least one aircraft-carrier on Yankee Station.

Above: Tests of the inflight refuelling technique were flown in May 1966 with a modified USAF CH-3C and a USMC KC-130 tanker. Note that the IFR probe was mounted directly in the nose on the prototype, instead of on the right side as on production HH-3Es.

The dedicated USAF H-3 SAR variant was the HH-3E. This 37th ARRS example flies alongside the HC-130P tanker after refueling over the South China Sea in April 1968. Search and rescue team tactics called for dropping the 200-US gal (757-litre) external fuel tanks whenever ground fire or heavy anti-aircraft fire were encountered.

gun mounts in the forward doors, which could accept either the M60 LMG or the General Electric GAU-2B 7.62-mm, electrically-driven Gatling gun, which had a rate of fire of up to 6,000 rounds per minute. For missions deep into North Vietnam, the 'HH-3C' had a 650-US gal (2460-litre) internal fuel tank, over 200 US gal (757 litres) more than the CH-3C, and under the main landing gear sponsons it was plumbed to accept a pair of 200-US gal drop tanks that had originally been designed for the F-100 Super Sabre. This brought the unrefuelled range of the HH-3E to 750 miles (1210 km).

Still, Air Rescue Service wanted more. Would it be possible to refuel a helicopter during flight? The massive main rotor blades precluded the use of the Boeing flying boom system, but a probe and drogue was possible. The main problem would be overcoming the heavy downwash from the main rotor. A standard refuelling boom as found on fighter aircraft could not be used because it would bend in the downdraft. Sikorsky came up with an inflight refuelling system that used a very long, very heavy refuelling boom experimentally installed in the nose of a CH-3C.

Inflight refuelling

To be successful, inflight refuelling required that special flight techniques be developed. Two major forces acted on the aircraft involved. The tanker aircraft left a tremendous slipstream and turbulence behind it through which the 'HH-3C' had to fly and make a successful probe of the IFR drogue. The helicopter's main rotor created a downward blast of air that also acted on the refuelling probe and drogue, but which could be overcome by placing the IFR probe just outside the radius of the rotor.

Major Harry Dunn, USAF, thought that perhaps the hull of the HH-3E could act like a boat on water and 'float' on the wave of air created by the slipstream of the tanker, rather than try to fly through it. Major Dunn was proven correct and successful testing was conducted at Wright-Patterson AFB in May 1966. The test flights were completed in the summer. Although the tests were successful, design refinements, crew training in the HIFR technique, and installation of the necessary refuelling equipment aboard HC-130Hs kept the inflight refuelling-equipped HH-3Es out of combat until mid-1967. Additional equipment installed on the HH-3E included a 600-lb (272-kg) capacity electric hoist, with a 240-ft (73-m) jungle penetrator. The five-man crew of an HH-3E 'Jolly Green Giant' included two pilots, one flight engineer and two PJs.

In mid-1965, the air rescue detachments throughout Southeast Asia were formed into a single unit. On 1 July, Det 3, Pacific Air Rescue Center was redesignated the 38th Air Rescue and Recovery Squadron (ARRS), headquartered at Tan Son Nhut and having detachments throughout South Vietnam and Thailand. Det 1 was at NKP on the Thai/Laos border, Det 2 was at Takhli, Det 3 was at Ubon, Det 4 at Korat, Det 5 at Udorn, Det 6 at Bien Hoa, Det 7 at Da Nang, Det 9 at Pleiku, and Det 10 was at Binh Thuy in the Mekong Delta region. With the exception of the CH-3C-equipped detachment at NKP, all were equipped with HH-43s until 10 November 1965, when the first six 'HH-3C Jolly Green Giants' were delivered to Udorn. One of the original CH-3Cs had been shot down on 5 November, and the remaining CH-3C was returned to TAC in January 1966.

An example of the cost of a typical rescue mission was that involving JOLLY GREEN 85, one of the original CH-3Cs. On 5 November 1965, Lieutenant Colonel G. C. McClearey's 357th TFS F-105D Thunderchief was shot down by a North Vietnamese surface-to-air missile, going down about 60 miles (96 km) south of Hanoi. The SARTF from Udorn went into action. A pair of A-1Es, callsigns SANDY 11 and 12, cruised to the spot where McClearey's F-105 had gone down. North Vietnamese anti-aircraft fire shot SANDY 12 out of the sky and the pilot, Captain R. E. Bolstad, bailed out. SANDY 11 circled until he located Bolstad and radioed the CROWN SC-54D to dispatch a rescue helicopter and another flight of SANDYs. JOLLY GREEN 85, a CH-3C, had just arrived over Bolstad's position when North Vietnamese small arms fire fatally hit the 'Jolly Green' helicopter. Captain Warren Lilly, pilot of JOLLY GREEN 85, nursed the stricken helicopter up to a proper bailout altitude, and ordered the crew out. Four parachutes were seen and one of the SANDY A-1s soon picked up a beeper from one of the crew.

The second CH-3C had developed mechanical problems en route to the original rescue site and was unavailable for a rescue attempt on either the downed A-1 or CH-3C crews. However, the Navy had an SH-3 Sea King from USS *Independence* in the area and offered to help. Escorted by SANDY 13 and 14, the SH-3 made its way to the downed crews. En route, SANDY 14 encountered 37-mm tracers and was shot down. SANDY 13 and the Navy SH-3, NIMBLE 62, searched the area where SANDY 14 had gone down, but found no trace of the aircraft or pilot. Now on 'bingo' fuel, both the Navy helicopter and SANDY 13 returned to refuel. After refuelling, NIMBLE 62, now escorted by Navy A-1Hs, proceeded to the site of SANDY 14. Finding nothing, they went on to where SANDY 12 and JOLLY GREEN 85 had gone down.

The Navy A-1s picked up a low beeper, and ordered NIMBLE 62 in to take a look. As the Sea King hovered over the jungle, the co-pilot saw a small light. The penetrator was lowered and retrieved the PJ from JOLLY GREEN 85. It was his Zippo lighter that had been the sole light source seen through the dense jungle canopy. The next morning, NIMBLE 62 and its escort of A-1Hs returned to the scene of JOLLY GREEN 85's crash, but heavy small arms fire just over the coast of North Vietnam brought the mission to a sudden halt. NIMBLE 62 went down, and the Navy A-1s were soon

Here a Det 7, 38th ARRS 'HH-3C' undergoes maintenance on the ramp at Da Nang in November 1967. Despite the conditions in which this work was carried out, the in-commission rate of the 'Jolly Greens' was way above standard. The placard to the right reads, "FIGHTER PILOTS DON'T FEAR, THE JOLLY GREEN GIANT IS ALWAYS NEAR, DET 7 38TH ARRS".

Above: A 37th ARRS HH-3E refuels over Laos in April 1968. The 'Jolly Green' would 'float' on the slipstream of the tanker aircraft during refuelling. The HH-3E was the first helicopter in the world with this capability, developed specifically for the mission in Southeast Asia.

Below: Sgt Joe McCusker stands by the revetment signs at Da Nang. The ribbons are for the Presidential Unit Citation and Outstanding Unit Award gained by the 37th ARRS.

involved in a gunfight with North Vietnamese anti-aircraft. Although both A-1s were heavily damaged, they radioed for a second Sea King from the *Independence*. The A-1s crashed at Da Nang as NIMBLE 63 was pulling the crew of NIMBLE 62 from the jungle.

The next morning, 8 November, a major task force of Air Force and Navy A-1s, SH-3s and the remaining CH-3 from Udorn converged on the remains of JOLLY GREEN 85. Navy F-8s from the *Independence* and F-100s from Da Nang provided MiGCAP. Two Air Force SANDYs picked up a beeper, but were immediately brought under attack by North Vietnamese heavy anti-aircraft fire, which damaged both Skyraiders. The rescue centre at Tan Son Nhut made the fateful decision to abandon any further rescue efforts, as the North Vietnamese had laid a well-designed flak trap around the crash site.

It was later learned that the crew of JOLLY GREEN 85 had been captured almost immediately, and were already on the way to the 'Hanoi Hilton'. Total cost for the mission was four A-1s, counting the two Navy aircraft that made a wheels-up landing at Da Nang, one CH-3C, one SH-3A, and heavy damage to several other Air Force and Navy A-1s. The attempt was not entirely fruitless, for the PJ from JOLLY GREEN 85 had been rescued. It was learned later that Lieutenant Colonel McClearey, the object of the original rescue attempt, had been killed in the SAM attack on his aircraft.

The second major reorganisation of the Air Rescue Service came on 8 January 1966 when it became the Aerospace Rescue and Recovery Service. In Southeast Asia, the 3rd Aerospace Recovery Group was activated at Tan Son Nhut, with control over the Joint Search and Rescue Center. At Da Nang, the HH-3E-equipped 37th Aerospace Rescue and Recovery Squadron (ARRS) was activated with a detachment at Udorn and was charged with aircrew recovery in North Vietnam, Laos and in the Gulf of Tonkin. The HH-43-equipped 38th ARRS retained most of the detachments throughout Southeast Asia, and its primary mission became local base rescue and aircrew recovery within South Vietnam.

Specialist Hercules

One other major change took place in 1966 – introduction of the Lockheed HC-130H as the primary airborne controller aircraft. The HC-130H had all the latest electronic SAR equipment, including the AN/APX-65 IFF interrogator to monitor all IFF frequencies active in the skies over North Vietnam. In addition to the APX-65, the aircraft was equipped with the AN/ARA-25 UHF/VHF homer, and various rescue equipment such as the ARK-1 raft kit and first aid equipment, all of which was air-droppable. The heart of the HC-130H was the Cook AN/ARD-17 Aerial Tracking System. Developed for NASA to locate downed spacecraft, the ARD-17 could be tuned to the frequency of the beepers attached to all the flight crews operating over North Vietnam. The extremely long range of the ARD-17 meant that the HC-130H could orbit over South Vietnam, Laos or the Gulf of Tonkin, and direct an entire SARTF operation almost anywhere over North Vietnam with impunity. The first two HC-130H aircraft arrived in December 1965, replacing the HC-54D Rescuemasters at Udorn. In June 1966, three more HC-130Hs arrived, and the five Hercules controllers became Detachment 1, 37th ARRS. On 16 January 1967, Det 1 was officially redesignated as the 39th ARRS.

In mid-1966, flight testing began on the inflight-refuelling capability of the 'HH-3C' helicopter using a modified KC-130 tanker loaned to the USAF by the Marines. With flight testing completed and highly successful, the Air Force gave formal approval to convert 11 HC-130H controller aircraft into tankers. Lockheed/Marietta installed several additional fuel bladders in the HC-130H, which held a total of 48,500 lb (22000 kg) of fuel, plus the

ORDER OF THE
JOLLY GREEN GIANTS
Be it known that
SGT JOSEPH G. McCUSKER
is admitted to the order of
the Jolly Green Giants
by having served as a member
of the 37 ARRS at DANANG RVN
from SEP 67 to SEP 68
OPERATIONS OFFICER
COMMANDER

The 'Order of the Jolly Green Giants' was bestowed on all 37th ARRS personnel completing their tour of duty. The 'Giant' was that depicted on Det 7's scoreboard at Da Nang. The parachute symbols marked rescues undertaken using the jungle penetrator.

Right: Equipped with Fulton STAR recovery gear, the HC-130H used its Cook AN/ARD-17 Aerial Tracker, atop the forward fuselage, to pinpoint transmissions from the locator beacons carried by aircrew. Though primarily used to recover agents, Fulton STAR equipment proved its worth in rescuing aircrew.

Below: This HC-130H from Det 1, 37th ARRS is seen at Korat in 1966. The HC-130H began replacing the HC-54D in December 1965 as airborne controller over Laos and North Vietnam.

necessary plumbing, pumps and drogue kits mounted in pods under the outer wings. Each tanker aircraft could refuel two HH-3Es simultaneously, although it was rarely performed in combat. The modified aircraft were redesignated HC-130P, and initial deliveries began in November 1966.

The detachment at Udorn, formerly Det 1, 38th ARRS, became Det 2, 37th ARRS, before finally being redesignated the 40th ARRS in March 1968. By the end of 1966, the SARTF team in Southeast Asia totalled 50 aircraft, including five HU-16B Albatross aircraft at Da Nang, 29 HH-43B/Fs for local base requirements throughout South Vietnam and Thailand, 10 HH-3E 'Jolly Green Giants' at Udorn, and six HC-130H/Ps also based at Udorn.

With the tools in place, the SARTF team set down standard operating procedures for the 'typical' rescue mission. Although all SAR missions in Southeast Asia started out 'typical', most ended up as organised chaos due to the uncertainty of combat and the North Vietnamese forces. A typical mission would call for a SARTF team made up of airborne controller aircraft, two recovery helicopters, and a flight of armed fighter aircraft. The airborne controller aircraft was the HC-130H/P Hercules, callsign CROWN. CROWN monitored all the frequencies of the strike forces, both Air Force and Navy. The CROWN controllers were listening for any signs of trouble, such as MiG warnings from the College Eye AWACs aircraft, SAM launch warnings from the Iron Hand flights, and normal radio traffic regarding anti-aircraft sightings. If an aircraft developed trouble of any kind, CROWN would alert the rest of the SARTF team for action.

With the HH-3E came the need for a tanker aircraft, the resultant HC-130P featuring a hose-drogue pod under each wing. This HH-3E from Det 7, 37th ARRS at Da Nang takes on fuel over the Gulf of Tonkin in June 1970. The HC-130P was capable of refueling two 'Jolly Green' helicopters at once, although it was rarely done in combat.

The first to be alerted and scrambled were two HH-3Es, callsign JOLLY GREEN. In 1966/67, they were based at Udorn and NKP in Thailand, and at Da Nang in South Vietnam. Many times these aircraft would stage to forward operating locations (FOLs) nearer to North Vietnam. Using the old Air America Lima Sites in Laos, the helicopters would be only minutes from the North Vietnamese border. Lima Sites 98 (Long Tieng) and 36 (Na Khang) north of the Plain of Jars were the most frequently used. HH-3Es from Da Nang often flew to FOLs in Quang Tri province along the DMZ. At the height of a strike into North Vietnam, the JOLLY GREENs would often launch and orbit at around 10,000 ft (3048 m) just outside North Vietnam. When the IFR-capable HH-3Es became available, they would orbit with the CROWN aircraft, taking on fuel as needed.

Rescues in the Gulf of Tonkin were handled by either HU-16Bs or 'Jolly Green' helicopters from Da Nang, Navy Sea King helicopters, or Navy ships patrolling the Gulf. All these forces were part of the total SARTF team, receiving instructions from the Joint Search and Rescue Center at Tan Son Nhut. The CROWN controller could call upon any of the SAR assets available from any source during a rescue attempt. Indeed, many of the rescue attempts in the Gulf of Tonkin or in eastern North Vietnam used a combination of Air Force and Navy aircraft as a team. There was no inter-service rivalry when a pilot was down. Navy A-1s from the carriers on Yankee Station often escorted Air Force HU-16Bs operating in the Gulf. The 3rd ARRG even devised a procedure in which an Air Force 'Jolly Green' helicopter could take on fuel from a Navy ship if necessary. It was called Operation High Drink, and the HH-3E could either land on the Navy ship or, in certain cases, hover close to the ship and have a refuelling hose passed over.

Last HU-16B sortie

On 30 September 1967, the last HU-16B sortie was flown. The big Albatross flying-boats had been in action as both airborne controllers and recovery aircraft from the beginning of US involvement in Southeast Asia. During that time, Albatross crews had saved 47 aircrews – 26 Air Force and 21 Navy. Four HU-16Bs had been lost in combat, with the loss of nine crew members.

The ResCAP flight was almost always flown by Douglas A-1 Skyraiders, both Air Force and Navy. The Air Force flights used the callsign SANDY. As soon as the 'Jolly Greens' scrambled for a rescue attempt, the SANDY flight would take off. It was usually a flight of four aircraft, broken into two tactical elements – SANDY HIGH and SANDY LOW. However, if only two aircraft were available, they broke the two-ship element into single aircraft as HIGH and LOW. The SANDY LOW aircraft would speed to the rescue site pinpointed by CROWN or another aircraft on the scene; SANDY HIGH escorted the 'Jolly Greens' to the area. The 'Jolly Greens' were also designated HIGH and LOW, with JOLLY GREEN LOW being the initial recovery helicopter. Arriving on the scene of the downed flier, SANDY LOW LEAD would

'Up north' in JOLLY GREEN HIGH

Left: Major Jim Elkinton was one of the 37th ARRS HH-3E 'Jolly Green Giant' pilots, seen here at Da Nang in 1969. It was standard practice to leave all unit patches, etc., off the flying suit for combat missions.

Right: An HH-53 receives a 'top-up' from an HC-130P over the South China Sea. The so-called 'Super Jolly Green Giant' arrived in Thailand in 1967, two HH-53Bs joining Det 2, 37th ARRS at Udorn in September.

We maintained an alert crew at Da Nang that briefed with the SANDY flights every morning at sun-up. We were briefed about any and all scheduled missions for the day, any new threats or changes in enemy activity (i.e., AAA, MiGs, SAM sites, etc.) and, of course, weather.

I was on the schedule board as the pilot of CHARLIE 2, the JOLLY GREEN HIGH bird. It should have meant I would have a quiet day. Alpha Flight was the primary alert aircraft, Bravo Flight would be on secondary alert, and so on. As our team resources were used, additional flights would be put together until we ran out of crews, aircraft, or both.

On 30 June 1970, a SAR mission was requested up north: seems an observation aircraft had poked its nose into something up on the DMZ that 'Charlie' did not want seen, so they shot the FAC out of the sky. The pilot was killed with the first burst of AAA, but the observer got out of the aircraft. Alpha Flight was scrambled for the SAR.

We had a radio in the operations hut, over which we could monitor the frequencies and get an idea of what was going on. The KING HC-130P command aircraft was relaying everything back to our headquarters.

Everything sounded like it was going right by the book until JOLLY LOW got into the hover position over the O-2 observer. That was when 'Charlie' opened up, driving off the 'Jolly Green' and inflicting substantial damage. The Bravo Flight SAR team then scrambled and headed east. This mission was starting out according to 'Charlie's textbook on flak traps, so I knew what was coming next. I went down to my locker, got my helmet, pistol and equipment, and headed out to my chopper.

This was at a time when the 37th ARRS was transitioning from the HH-3E to the HH-53C. At the time of this mission, the squadron was equipped about half and half. And since I was a short-timer with less than two months left in my tour, as was 'Blake' in Charlie JOLLY GREEN LOW, both of us had the HH-3Es.

The scramble horn sounded and I was all strapped in and ready to go. No running across that hot tarmac for me. Flight Lead was the CO of the 37th, Lieutenant Colonel Al Holcomb in one of the HH-53Cs. We scrambled on our usual coastal route heading north. About half way up the coast, we received a situation briefing.

A second rescue attempt had met with disaster. Bravo Flight's JOLLY LOW HH-53C had been hit by a North Vietnamese rocket-propelled grenade, crashed and exploded, killing all nine crew members. The SANDY flights were engaging the enemy AAA, and getting the area ready for the next SAR attempt. The mood was pretty sombre at this point. The loss of the HH-53C and crew isn't the kind of news one wants to hear, especially when you're about to enter the same area.

We turned inland short of Quang Tri and proceeded to an area about 75 miles to the northeast. A flight of SANDYs met us and escorted us to a holding area while the other SANDY flights worked over the area where the observer was located. It was getting late in the day and it looked like we would only have time for one more attempt before darkness.

SANDY LOW, the on-scene commander, briefed us on the next attempt. The SANDYs were going to lay smoke and CS gas over the area. The JOLLY LOW helicopter would go in with the crew wearing flak vests and gas masks. JOLLY HIGH would stand by. At last, SANDY LOW thought the area was acceptable and directed 'Blake' in JOLLY LOW to start his run.

No answer. Some garbled voices. JOLLY LOW had suffered a radio failure at just the wrong moment. Everything was in place. It was do it now or start over in the morning. SANDY LOW called me and asked if I could take over as JOLLY LOW, the primary recovery helicopter. Was I ready to go? I wasn't, but I said I was, and I started my descent.

We had been holding at several thousand feet to stay out of the ground fire. The rapid descent and high humidity causes the windshield to fog up. We were all trying to put on our flak vests and gas masks while still maintaining descent, speed and control. It was kind of like a Chinese fire drill for a couple of minutes.

At last we were skimming over the tops of the trees. Suddenly, the radio came alive as SANDY LOW reminded me that I still have my external fuel tanks. In the excitement, I'd forgotten the SOP. Damn! I punched them off and hoped they'd hit some 'gomer' on the head.

The windshield cleared and SANDY LOW lobbed a couple of Willie-Petes [White Phosphorous smoke rockets] into the area. One hit long and the other short of the downed observer. The gas had already been dropped and I had SANDYs on each side of me laying in suppression fire with both the Minigun and the cannon. I kept the speed up for as long as I could before coming into an abrupt hover.

At the time, I was monitoring only the GUARD channel. All I wanted to hear was the intercom from my own crew, the survivor's radio, and SANDY LOW. The observer popped smoke, and my PJ spotted it and gave me directions to the guy. The survivor had indicated that he needed some type of assistance, so the PJ rode the jungle penetrator down to the ground.

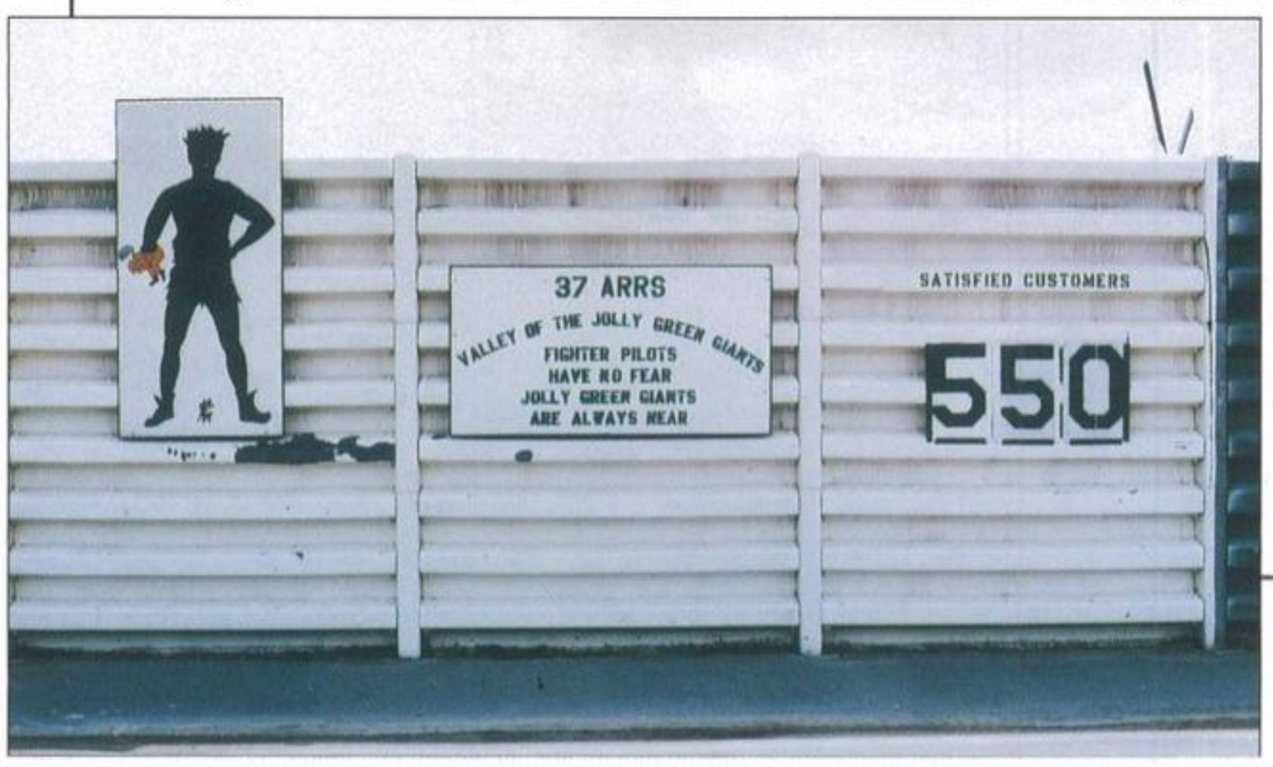
The SANDYs were in a daisy chain orbit, laying down suppressing fire, but we were still taking ground fire. It sounded like a popcorn machine in a movie theatre. It was AK-47 fire, I'd heard it before. I didn't hear anything heavy. With that damn mask on and the smoke filling the cockpit, I had very limited visibility. It took all my concentration to maintain a precise hover. I spotted an area downhill from where we were, to put this thing down if I had to.

My PJ had the observer and was in the process of bringing up the cable. We were still taking hits, but everything was running well and all the gauges were still 'in the green'. The hoist operator reported that both the PJ and the observer were aboard and secured. SANDY LOW advised me that the best egress route from the area was to the south, and we moved out at full speed, staying at treetop level until SANDY LOW advised me that we were clear of the hot area.

I started to climb to cruise altitude, and asked the rest of the crew to check for any battle damage. We were also getting very close to bingo fuel status, so I requested a refuelling from the HC-130 KING tanker orbiting well out of range. The crew checked the bird over and reported that there were many, many bullet holes in the fuselage. I decided that we better put down at the first safe place and check the exterior before proceeding back to Da Nang.

KING came down from altitude and reeled out the drogue hoses. I took on a full fuel load, broke off and thanked KING, and headed for Quang Tri. It was dark when we landed. A quick inspection revealed extensive damage to the rotor system, and several of the blades had been holed. We put our bird into a revetment at Quang Tri, and boarded the JOLLY HIGH bird for the return trip to Da Nang. The observer who we plucked from the jungle had only one thing on his mind the whole trip home – spilling his guts to the intelligence people. He did not tell us anything, and we never did find out what he'd seen.

Captain James Elkinton, 37th ARRS
Da Nang, 30 June 1970



The rescue units were rightfully proud of their achievements, and none more so than the 37th ARRS. This sign on the revetments protecting the HH-3/HH-53 helicopters proclaims the total of 550 aircrew retrieved by the time the photo was taken at Da Nang in 1969.

An HC-130P is seen here over the Gulf of Tonkin in June 1970. Fuel for replenishing probe-equipped HH-3s was held in bladders in the fuselage cargo bay.

take over as on-scene commander. His element would attempt to locate the exact position of the downed flier, reconnoitre the area for enemy troops or anti-aircraft weapons (AAA), and contact the flier on the ground. If enemy troops or AAA were encountered, SANDY LOW flights were well armed to take on almost anything.

A normal SANDY ordnance load usually consisted of four to six 250-lb bombs with fuse extenders, a pair of 100-lb white phosphorous bombs, a single SUU-11A/A 7.62-mm Minigun pod, several LAU-3 rocket pods, various CBU launchers, and the internal 20-mm cannon. Included among the many types of CBUs carried by the SANDYs were such exotic weapons as the CBU-19 tear gas bombs, and the CBU-30A area denial weapon, often referred to as 'gravel'. The SANDY would cover an area around the downed flier with 'gravel', which looked like small rocks or animal droppings on the ground. As the 'gravel' warmed, it became active and exploded if stepped on. The CBU-19 tear gas weapon was especially effective in subduing enemy anti-aircraft crews.

After SANDY LOW LEAD had determined that the area was reasonably secure, and the downed flier's location was pinpointed, he would call for JOLLY GREEN LOW to make the recovery. The 'Jolly Green' would hover over the downed flier and lower the penetrator through the trees. If the downed man was injured or unconscious, a PJ would ride the penetrator down, make emergency medical decisions (dress wounds, splint broken limbs, etc.), then fasten the airman to the penetrator, which hoisted him back to the hovering helicopter. The PJ usually had to wait on the ground until the flier was taken aboard the 'Jolly Green' and the penetrator was once again lowered to pick him up.

If JOLLY GREEN LOW came under fire, SANDY LOW LEAD would call for SANDY HIGH flight to suppress the enemy troops. SANDY LOW LEAD could also request other flights in the area, including strike flights inbound to a target, to lend assistance, or call for other SANDY flights which were sitting alert at the nearest base. If JOLLY GREEN LOW was hit and forced down, JOLLY GREEN HIGH would move in and pick up both the 'Jolly Green' crew and the original downed flier. Once the downed flier was recovered and aboard the Jolly Green, CROWN would call for a maximum CAP effort from all aircraft in the area. The 'Jolly Greens' and A-1s would then head for the border with throttles 'balls to the wall'!

With these aircraft and crews in place, and using the basic tactics developed for the combat rescue, 3rd ARRG had achieved the following by the end of 1966 – total rescued personnel, 647; combat aircrew recoveries, 222: non-combat aircrew recoveries, 55. Of the 222 combat aircrew rescues, 37 were inside North Vietnam, 39 in South Vietnam, 51 in Laos, and 26 from the Gulf of Tonkin. In 1966 alone, the 3rd ARRG plucked 179 men from the jungles of Southeast Asia during the height of the Rolling Thunder strikes. By the end of 1967, rescues performed by 'Jolly Green' crews had increased almost 25 per cent, from 92 in 1966 to 122 in 1967. Rescues by HH-43F 'Pedroes' remained almost static, going from 65 to 68. Of course, HU-16B recoveries dropped dramatically, from 22 in 1966 to 1 in 1967, as the aircraft was withdrawn from combat.

Enter the 'Super Jolly'

In late 1967, the first of the new 'super-lift' helicopters was delivered – the Sikorsky H-53. Designed and developed to recover the Apollo spacecraft, Sikorsky and the ARRS further developed the H-53 design to meet the needs of combat in Southeast Asia. It was designated the HH-53B 'Super Jolly Green Giant', and known to the crews as the 'BUFF' or 'Big Ugly Fat Fellow'. The HH-53B was huge compared to the HH-3E it would replace, almost twice as big. The HH-53B had a gross weight in excess of 36,000 lb (16330 kg), compared to 18,000 lb (8165 kg) of the HH-3E. With two very powerful T64-GE-7 Turboshaft engines rated at 3,925 hp (2928 kW), the HH-53B could lift over 13,000 lb (5900 kg); the HH-3E could lift about 3,000 lb (1360 kg) in combat configuration. Top speed of the HH-53B was almost 60 mph (96 km/h) faster, at 195 mph (314 km/h).

The HH-53B/C had the same avionics as the HH-3E, and the latter's inflight refuelling capability. Titanium armour plate surrounded the cockpit and extended under the floor of the passenger compartment to protect the five-man crew (two pilots, one flight engineer, and two PJs). Defensive armament consisted of two GAU-2B Miniguns mounted in the forward doors, and a third Minigun mounted on a tripod fixed to the rear ramp which was lowered in combat. The first HH-53Bs were delivered to the 37th ARRS crews at Udorn in late September 1967.

1968 began much as 1967 had ended – missions, missions, and more missions. Throughout all of Southeast Asia, the 'Jolly Greens', 'Pedroes' and newly arrived HH-53 'Super Jolly Green Giants' saved a total of 572 personnel in 1968. The 13th Air Force had about 1,300 aircraft in Southeast Asia, about 500 being based in Thailand and fighting over North Vietnam and Laos. The war over South Vietnam was not easy but, by contrast, the intense defences over the North – MiGs, SAMs, light and heavy AAA (all radar directed) – made any attack there an incredible test. At times it seemed like every old man with a rifle was firing at the strike aircraft, which was actually fairly common, and even an old man with a rifle can knock down a sophisticated fighter aircraft with a single lucky shot. Each aircraft that went down, no matter where it fell, brought a massive rescue effort to recover the downed American fliers.

On 30 January 1968, the North Vietnamese Army and Viet Cong launched the Tet Offensive. With that attack, most of the offensive air power in Southeast Asia was brought to bear against targets in South Vietnam and along the Ho Chi Minh Trail, so losses over North Vietnam started to decrease slightly. With the rapid defeat of the NVA and

A vital part of any SAR effort was the EC-121H AWACS aircraft, callsign COLLEGE EYE. The EC-121 crew warned the SAR team of the approach of any unidentified aircraft. On 28 January 1970 North Vietnamese MiGs succeeded in downing an HH-53B.

After a SAR pilot finished 100 missions over Laos or North Vietnam, he was rotated out of the combat zone. At the completion of his 100th mission he could expect a liberal dousing. Receiving the hose treatment is Major Frank Murray (above left), while getting a bucket upon leaving his A-1* The Proud American *is Colonel Ed Walsh, 56th SOW commander (left). Above, he celebrates in traditional style.

VC following the Tet Offensive, the Thailand-based squadrons were ready to resume the full-scale bombing operations of North Vietnam. However, President Lyndon Johnson was not.

On 31 March 1968, President Johnson ordered a halt to all bombing attacks north of the 19th Parallel. Targets in roughly half of Route Pack II (on the coast between Dong Hoi and Vinh) and all of Route Pack I (just north of the DMZ) could still be attacked. The NVA took immediate advantage of the halt and began moving more and more SAM sites and AAA into the area between the DMZ and the 19th Parallel. Close surveillance by Air Force and Navy reconnaissance aircraft managed to keep losses to a minimum over North Vietnam, and many US pilots now looked forward to completing their 100-mission tour in relatively safe skies. Losses over Laos, however, were a different story.

Negotiations with the North Vietnamese continued throughout the summer of 1968. President Johnson proposed that if the North Vietnamese agreed to several basic conditions – not to take advantage of a bombing halt to build up their forces along the borders of South Vietnam, not to attack US forces across the DMZ, not to support another major VC attack similar to the Tet Offensive, and to allow US reconnaissance flights over North Vietnam south of the 19th Parallel – President Johnson would halt all offensive air attacks anywhere in North Vietnam. The North Vietnamese readily agreed to the proposal, and on 31 October 1968 President Johnson ordered all air strikes against North Vietnam halted.

Reconnaissance flights

The reconnaissance aircraft that flew into North Vietnamese airspace were escorted by both MiGCAP and Iron Hand defence suppression flights. Any direct threat to the reconnaissance aircraft, e.g., 'illumination' or lock-on by an NVA radar, or something perceived as a possible firing pass by MiG fighters, could be immediately attacked by not only the escort flights but by other flights not involved in the actual mission. These attacks were known as 'protective reaction strikes', and they occurred anywhere in North Vietnam. Thus, American aircrews were in danger through the bombing hiatus years of 1968, 1969 and into 1970.

The search and rescue effort continued unabated even after the bombing halts were invoked. In 1969, 3rd ARRG saves totalled 481 throughout Southeast Asia; in 1970, the figure dropped to 176, reflecting the decrease in the number of missions flown.

The highlight of 1970 was the daring rescue raid on the North Vietnamese prion at Son Tay, where intelligence indicated about 100 US personnel were held. A bold plan was hatched to liberate the prisoners from the camp. However, both the plan and the intelligence were some four months behind the activities at Son Tay; the NVA had evacuated all the PoWs in mid-July, moving them to Dan Hoi Prison, about 7 miles (11 km) from Son Tay.

The Son Tay planners knew nothing of this, and on the night of 20 November 1970 the plan was put into action. It called for a SARTF composed of two C-130E Combat Talon aircraft, five A-1E SANDYs, five HH-53C 'Super Jolly Green Giants', and a single HH-3E, a co-ordinated effort by both Air Force and Navy aircraft. The Air Force supplied the actual recovery team, the MiGCAP, and Wild Weasel support over Son Tay, and the Navy provided a diversion that would occupy the majority of the NVA defences.

At 23.10, Udorn time, the SARTF team headed toward North Vietnam. The F-105G Weasel aircraft flew directly to Son Tay and began suppression efforts against the NVA SAM and AAA radars. The F-4 MiGCAP orbited over Laos, listening on the EC-121D College Eye frequencies for any sign of MiG activity. At the same time, Navy A-6s and A-7s made diversionary flights toward Haiphong – looking and sounding like a B-52 strike. The Navy also had several MiGCAP flights on airborne alert.

The recovery team aircraft went directly to Son Tay and began their operations. However, the first helicopters landed in the wrong compound, attacking an NVA sapper school about 400 yd (365 m) from the prison. After realising their mistake, the rest of the team proceeded to the prison. As the door gunners machine-gunned the guard towers, the HH-3E was deliberately crashed inside the prison compound. American troops immediately rushed the prison, and began searching all the cells for any signs of life.

At the sapper school, Colonel 'Bull' Simons' troops were involved in a firefight with NVA troops. At the prison, the two-man rescue teams searched in vain through the entire prison. Nothing! There was no one in the cell blocks. Finally, after exhausting all the search efforts, the rescue teams ran to a waiting HH-53C. Twenty-seven minutes after action began, the Son Tay raiders were en route back to Thailand. The plan had worked to perfection, with nothing to show for their efforts.

As the raiders were leaving North Vietnam, NVA SAMs streaked into the air. Two of the Weasels were hit; they managed to make it out of North Vietnam, but one came apart over northern Laos and the two-man crew ejected. An NVAF MiG got a shot at one of the HH-53s with an 'Atoll' missile, but missed. Two of the HH-53Cs that had been slated to

Firebird ***was an A-1J assigned to the 1st SOS at NKP in 1969. Air Commando units became Special Operations units in August 1968. The A-1 crews often referred to themselves as SPAD pilots and members of the 'Antique Air Force', due to the fact that they were still flying propeller aircraft in the new jet USAF.***

1st, 6th & 602nd SOS SANDY A-1s

The SANDY A-1s of the 1st and 602nd SOSs flew in two-ship teams as part of the SARTF force. One two-ship would go directly to the rescue site and reconnoitre the area, suppressing any enemy that they encountered. The other team would escort the 'Jolly Green' helicopters before joining in on any suppression duties the mission required. Missions often went right into the heart of North Vietnam, within scant miles of Hanoi.

Above right: A 1st SOS A-1H is seen over the Plain of Jars in northern Laos in 1970.

Below: **Magnet Ass**, *an A-1H assigned to the 1st SOS detachment at Da Nang in May 1970, is seen armed with unfinned napalm and SUU-14 dispensers. Unusually, the aircraft also carries two Minigun pods.*

Below: In 1970, as squadron A-1 assets were stripped for the Vietnamisation program, 7th Air Force authorised the activation of another unit in South Vietnam, the 6th SOS based at Pleiku. The 6th had a detachment at Da Nang (Forward Operating Location Alpha Alpha) for the SAR mission. **SuNan Sam** *flew with the 6th SOS when the detachment tailcodes were '6T'.*

Bottom: **Pumpkin Pie**, *an A-1H on SAR alert with the 1st SOS at NKP in October 1970, shows the typical asymmetrical ordnance load for a SAR mission, with an SUU-11A/A Gatling gun on the left wing pylon and a 300-US gal (1136-litre) drop tank on the right.*

Above: **Bubbles 'N Bust** *was an A-1J assigned to the 602nd SOS at NKP in 1970. The USAF acquired a number of A-1Js retired by the US Navy, to replace A-1Hs lost in combat.*

Below: **Cool Fool**, *an A-1H assigned to the 1st SOS at NKP in 1970, carries SUU-14 munition dispensers. These could drop many types of sub-munition, including CS or tear gas, CBU-30 'gravel' mines, and small bomblets.*

Above: A-1J **Tiny Tim** *was assigned to the 602nd SOS detachment at Da Nang in May 1970. SAR aircraft on five-minute alert had a special area at both Da Nang and NKP with signs indicating the aircraft had 'hot guns', i.e., the guns and ordnance were charged with rounds in the chambers.*

Below: **Stump Jumper** *was flown by the squadron commander of the 1st SOS at NKP in October 1969, as denoted by the multiple 'command bands' around the rear fuselage. The first SOS had all three A-1 types assigned – the A-1H and J, and the A-1E two-seat machines.*

A great number of USAF A-1s were lost during the war in Southeast Asia, largely due to the extremely hazardous nature of their mission. This 602nd SOS took a 37-mm hit in the wing-root area, but brought the pilot safely back to Ubon where he made a belly landing in January 1969. The aircraft was repaired and flew again.

recover prisoners refuelled from one of the C-130 tankers and went back to recover the Weasel crew. Driven off by intense small arms fire, they were forced to return to NKP empty. The following morning, a flight of SANDY A-1s arrived and rapidly dispatched the enemy gunners. The two 'Jolly Green' helicopters, which had been orbiting out of range with the HC-130P tanker, then moved in and pulled the Weasel crew from the Laotian jungle.

When newly-elected President Richard Nixon promised to 'Vietnamise' the war, the US Air Force began sending units home. Some returned to their home bases, others were deactivated, and many were transferred to other bases in Southeast Asia. Such was the case with the rescue forces, which were moved around to offer maximum SAR coverage with a diminished force. Many of the HH-43F 'Pedro' units were withdrawn completely. As a major unit was rotated out, the local base rescue detachment was simply dissolved.

Unit changes When the 12th TFW left Cam Ranh Bay, Det 8, 3rd ARRG was removed from the OT&E tables. Det 2 was deactivated at Takhli when the 355th TFW stood down. And so on, throughout the units within the 3rd ARRG.

The 11 HC-130Ps of 39th ARRS moved from Tuy Hoa to Cam Ranh Bay in mid-September 1970. On 1 July 1971, the entire 38th ARRS, the HH-43F unit with all the local base rescue responsibilities, was inactivated. The remainder of the HH-43Fs in Southeast Asia were placed under direct control of the 3rd ARRG. On 21 July, the 40th ARRS relocated from Udorn to NKP, sharing the ramp with the A-1 SANDYs from the 1st Special Operations Squadron (SOS).

As 1972 dawned, the 3rd ARRG's authorised HH-53 strength was reduced from 20 to 13 helicopters. In March 1972, 39th ARRS HC-130Ps moved from Cam Ranh Bay to Korat. When the NVA unleashed their all-out offensive on 31 March 1972, the 3rd ARRG was composed of the following units: two rescue co-ordination centres at Son Tra, RVN, and at Udorn, the 37th ARRS at Da Nang, the 40th ARRS at NKP, Det 3 at Ubon, Det 4 at Korat (which included the HC-130Ps), Det 5 at Udorn, Det 12 at the B-52 base of U-Tapao, and Det 14 at Tan Son Nhut. Easter 1972 found the NVA ready to attack, requiring an all-out response by Air Force and Navy resources. The co-ordinated response would result in thousands of sorties by American strike and rescue aircraft over North Vietnam during the next 10 months.

When the NVA launched their Easter Offensive, it caught most of the American generals by surprise. President Nixon's Vietnamisation programme had been underway for the better part of two years, depleting virtually every unit in Southeast Asia. Literally overnight, combat sorties doubled, then doubled again. With the increase in combat sorties came the inevitable increase in aircraft

SARTF SANDYs in action

I was the Operations Officer for the 1st SOS at NKP in the autumn of 1970, before taking over command of the squadron in early 1970. I flew the A-1 Skyraider on 64 sorties, which isn't very impressive considering that many of the guys in my squadron had well over 100 'counters'.

I recall one search and rescue mission that had all the ingredients of a Hollywood script. It took place in March 1971, as part of Operation Lam Son 713, an incursion into Laos by South Vietnamese Army troops (ARVN), across the DMZ toward Tchepone. In the course of this action, a US Army Huey, callsign WITCH DOCTOR 05, was monitoring the action of a group of ARVN senior officers. They were touring the front lines well beyond the advancing ground troops.

Closing on Tchepone, the Huey was hit by North Vietnamese (NVA) anti-aircraft fire, and was forced down in an area immediately adjacent to a group of NVA troops. The Huey crew and the passengers extracted themselves from the wreck of the chopper, and got into an old bomb crater that was near the main trail (Ho Chi Minh Trail) out of Tchepone. We launched the SARTF force on 5 March and headed toward the downed Huey.

While we were en route, a couple of forward air controllers were bringing in some Navy and Marine fighters to soften up the area prior to our attempted rescue. One of the Marine A-4 Skyhawks was shot down, which created another SAR effort. One of our 'Jolly Greens' was diverted to the downed Marine pilot, and we got him out without too much trouble.

However, while the rest of the SARTF force was working on the WITCH DOCTOR mission, one of the SANDY A-1s was hit by ground fire and started to burn. The pilot, First Lieutenant Chuck Tipton, used his 'Yankee Extractor device' and got out of the aircraft at a very low altitude. The 'Jolly Green' that he'd been escorting swooped in and picked him up in less than a minute. The 'Jolly Green' pilot then made an immediate turn and went straight back to NKP with Tipton aboard.

In the meantime, another US Army Huey, callsign DOLPHIN, decided that he could probably sneak in and pick up the WITCH DOCTOR crew and passengers. He made a rather vertical approach to the area, which made him an easy target for the NVA anti-aircraft, and was hit several times. He did make it out of the area, but his co-pilot was very badly wounded.

The call went out for another SAR force to launch out of NKP. That was me – SANDY 02. SANDY 01 and myself, along with a third 'Jolly Green' helicopter, left NKP and headed directly for the area of WITCH DOCTOR. When we arrived, we found we weren't alone, as several other A-1s had launched from Da Nang to support our effort. These guys were armed with smoke and CS gas dispensers.

The on-scene SAR commander ordered the smoke and gas to be put down, and our team started the approach to the WITCH DOCTOR crew, but the area was still too hot. Lots of heavy anti-aircraft (AAA) fire started to blossom around both my flight and the 'Jolly Green'. As soon as the AAA opened up, the 'Jolly Green' beat a hasty retreat, and stood by, out of range of the big guns. My flight started working over the NVA gun positions that had shot us off our mission. SANDY 01 killed a ZSU (23-mm twin-mount on a tank chassis) that was near WITCH DOCTOR's position. I got a 37-mm gun that had set up about a mile away.

Since the area was still very hot, and darkness was approaching, the decision was made to abandon the effort for the day. Before we left, one of our younger pilots, who had been working on a scheme to air deliver supplies to downed personnel, decided to give his idea a try. He'd been working on a high-speed delivery capsule that was made from the shell of an air-dropped flare. He'd rigged up a drogue 'chute for the thing. Inside the capsule was a URC-10 rescue radio and spare batteries, some water, hand flares, and a few meagre rations. After two passes over WITCH DOCTOR, he made a successful drop.

The next morning NKP was alive with activity as the ground crews armed the aircraft and helicopters for another try at WITCH DOCTOR. Before we got to the point of "Start engines!", we were informed that WITCH DOCTOR, his crew and passengers, were safe and sound. They'd been rescued by an ARVN M48 tank that had been part of the original Lam Son 713 effort – which is what should have been used for the rescue effort in the first place.

Major Frank Murray
1st Special Operations Squadron
Nakhon Phanom, March 1971

A CH-3C 'Jolly Green Giant' gets 'down in the grass' of North Vietnam in 1966. The cargo hoist was used as a rescue winch on the CH-3Cs, 'HH-3Cs' and HH-3Es having a smaller winch fitted for the purpose, above the forward fuselage door on the starboard side. Tactical camouflage was introduced on the SAR helicopter force from 1965.

A 40th ARRS HH-53C heads over the mountains of Laos for a possible rescue attempt in North Vietnam in 1969. The rear ramp was lowered for all missions over 'Indian Country', i.e., over Laos or North Vietnam, so that the rear Minigun could be used. Note that the fuselage insignia is painted on a placard, removed for missions into countries which were not officially involved in the war.

A crewman looks on from his HC-130P as it refuels an HH-53, somewhere in the skies over Vietnam. Unlike that fitted to the HH-3E, the HH-53's IFR probe was retractable.

and crew losses. Combat losses over North Vietnam in 1971 had totalled only six aircraft for all services, but by the end of 1972 it was 149 aircraft.

Vietnamisation SAR reductions

Part of the Vietnamisation programme called for a drastic reduction in the ResCAP force of A-1 SANDY aircraft and the Air Force had been transferring A-1s to the VNAF for over two years. From a high of six squadrons, the only A-1 unit available when the NVA attacked was the 1st SOS at NKP. The air rescue helicopter force had also been drastically reduced, to fewer than a dozen HH-53s in spring 1972. The SARTF team was totally inadequate for the task that lay ahead.

The figures for the first few months of the Linebacker operation were slightly out of focus with regards to the force size mentioned above. In April, 3rd ARRG units saved 12 men, 10 being combat rescues in North Vietnam. In May, the total jumped to 138 men saved – the highest for any month of the war – only one of whom was a downed flier in North Vietnam. Most of that 138 came in a daring rescue of 132 American and ARVN troops surrounded in the old Citadel in Quang Tri City. Four HH-53s from the 37th ARRS left Da Nang on 1 May, three of which landed inside the walls of the Citadel and pulled out the 132 men. The fourth HH-53 was about to leave the area when additional calls for help came from inside the Citadel. Immediately, the fourth 'Jolly Green' returned and put down inside the walled area. Lowering the ramp, they waited for the 'friendlies' to run out and board.

It was a trap. NVA small arms fire poured into the idling helicopter. The PJ door gunner opened up with his Minigun, and the HH-53 pilot, Captain Donald Sutton, lifted off and headed back to Da Nang.

One of the most famous rescue attempts occurred just three days after the initial NVA attack. On 2 April, an EB-66E from the 42nd TEWS, callsign BAT 21, was escorting a cell of B-52Ds attacking targets across the DMZ. Unknown to any of the American crews, the NVA had moved several SA-2 batteries into the area. One of the SA-2s hit BAT 21, the only survivor being Lieutenant Colonel Iceal Hambleton, the electronic warfare officer. Hambleton was no ordinary EWO, though: he had previously been stationed at SAC Headquarters, and had the strategic targeting information in his head. Everyone in Southeast Asia knew it, especially the NVA.

Both the 3rd ARRG and the NVA were about to make a maximum effort to get to Hambleton. As the NVA moved in on Hambleton, 1st SOS A-1 SANDYs began their strafing runs. Four Army UH-1 Hueys braved the intense ground fire but had to turn back after one was shot down, and a second crashed on the Quang Tri beach several miles to the east. The A-1s flew sortie after sortie trying to keep the NVA soldiers away from Hambleton, including surrounding him with a belt of 'gravel' that extended for ¼ mile (400 m). The NVA moved even more AAA and SAMs into the area.

For 10 days, the 7th AF made strike after strike, and several rescue attempts. NVA SAMs brought down two OV-10 FACs, and an HH-53 rescue attempt ended in disaster when the 'Jolly Green' was shot down with the loss of the entire crew. Finally, 11 days after being shot down, Hambleton made his way to the Cam Lo River and floated downstream to a waiting US Marine unit, which quickly took him to a waiting helicopter. The whole operation highlighted the inadequacies of the rescue forces operating in Southeast Asia when pitted against a modern electronic defence.

New SAR systems

Of course, equipment existed that would make the SAR forces more capable of entering North Vietnamese airspace and surviving, and it had been installed in both Air Force and Navy aircraft for many years. Electronic countermeasures pods and radar homing and warning equipment had been available since the early 1960s. It was not suitable for helicopters, nor for the slow-moving A-1 SANDY ResCAP aircraft, for it was either incompatible with the aircraft systems or too heavy/large to fit under the helicopter. New systems were being perfected, but none arrived in time for the Linebacker I or II raids.

The ResCAP mission that had been flown so capably by the A-1 SANDYs was being taken over by the Ling-Temco-Vought A-7D. Two of the additional units rushed to Southeast Asia for the Linebacker operations were the 3rd TFS and 354th TFW, equipped with the A-7D. In late October 1972, a meeting was held at NKP between the 7th AF, 1st SOS, 3rd ARRG, and

A CH-53C 'Knife' helicopter on the ramp at NKP in 1973. The 'Knife' helicopters were used for clandestine missions into North Vietnam and Laos, with a limited rescue capability. 'Knife' CH-53s from the 21st SOS were involved in Operation Frequent Wind, the evacuation of the US Embassy in Saigon during May 1975.

These HH-53Cs are seen on the ramp at NKP in 1969, assigned to the 40th ARRS. In the background are HH-3Es of the 37th ARRS.

The typical SARTF team in late 1968 consisted of an HC-130P KING tanker aircraft, a pair of A-1 SANDY aircraft, and usually two HH-53C 'Super Jolly Green Giant' helicopters.

the operations people of the 3rd TFS. The subject – could the A-7D assume the SANDY role as part of the SARTF team? The decision was yes. On 2 November 1972, the 7th AF placed 12 A-7Ds on ResCAP alert status on a daily basis. On 7 November, the last A-1 SANDY mission was flown. On 15 November, the last A-1H/Js from the 1st SOS were transferred into the VNAF.

There were many problems in replacing the A-1 with the A-7D. The A-1 had a much greater 'loiter time' over a target area. The A-7D burned fuel at a very high rate, and had to constantly shuttle back and forth to a KC-135 tanker. Both aircraft could carry comparable maximum ordnance loads, but the A-7D had much more sophisticated bombing systems and radar. However, this was tempered somewhat by the type's high speed, which also meant it had to fly a 'race-track oval' around the HH-53s during escort to the target area. The A-7D was much better equipped to survive the radar-infested area of North Vietnam.

The A-7Ds flew their first combat rescue mission on 16 November, when a Wild Weasel F-105G was hit by a SAM. It took three days to complete the recovery, but both Weasels were successfully rescued.

One other aircraft type had been added to the SARTF team in 1970 – the Rockwell OV-10 Bronco. These high-speed, propeller aircraft became the low-level 'eyes' of the SARTF team. Capable of carrying several canisters of rockets or bombs, and having four 7.62-mm machine-guns in the stub wings, the OV-10 often took the place of the A-1 SANDY as the force of that aircraft decreased. By the time the Linebacker operations were in full swing, many of the 23rd Tactical Air Support Squadron (TASS) OV-10s were equipped with the Pave Nail/Pave Spot night observation/laser designator pod, which allowed the OV-10 to 'illuminate' a target for laser-guided munitions dropped by another aircraft, or to work with an aircraft such as the AC-130 Spectre gunship during night rescue attempts.

Even with the influx of upgraded system and aircraft, and an increase in both helicopters and personnel, the SARTF team was able to do very little during the next operation of the war – Linebacker II. In late October 1972, the US and North Vietnam had appeared to have a negotiated peace, but by mid-December the North Vietnamese had not signed any of the agreements; instead, they walked out of the negotiations on 13 December. President Nixon ordered the all-out bombing campaign known as Linebacker II. The great cities in the North would be subjected to bombing by every available type of aircraft, including the Boeing B-52 Stratofortress. It was the first time the big B-52s would be pitted against 'the most sophisticated air defence system in history', and losses were expected to be very heavy. SARTF forces were alerted for a maximum effort.

Linebacker II

Linebacker II began on 18 December when 48 B-52s struck the North Vietnamese airfields at Kep and Hoa Lac. Before the sun rose again, 81 more B-52s had hit targets in North Vietnam. Flying with them were hundreds of support aircraft – F-111s and Wild Weasel F-105Gs hit the SAM sites, Air Force and Navy F-4s flew MiGCAP patrols, Navy A-6 Intruders flew both attack and mining operations over Haiphong, and EB-66Es jammed the North Vietnamese radars. The night sky over Hanoi was lit like daylight with AAA explosions and SAM rocket launches – and with aircraft on fire. Losses on the first night included three B-52s, an F-111A, and an OV-10A.

The Linebacker II campaign continued over

Left: This HH-53C was assigned to the 37th ARRS, which had a detachment at Da Nang in 1970. For defence against enemy ground fire, the HH-53B/C had titanium armour plate around the cockpit and under the floor, and was equipped with three GAU-2B Miniguns in the forward doors and on the rear ramp.

Below left: A downed flier is pulled through the open door of a 40th ARRS HH-53C, after being recovered from the jungle of North Vietnam in 1969. Although the bombing halt had been in place since October 1968, reconnaissance missions were still being flown over North Vietnam to monitor any build-up of troops and equipment. The dense jungle of Southeast Asia may be appreciated from this photograph.

Below: A PJ from the 37th ARRS rides the jungle penetrator up through the trees with an unidentified F-105 pilot in 1967. The jungle penetrator had a cable 200 ft (61 m) long, which was needed in Southeast Asia where many of the trees grew to over 150 feet (45.7 m) in height.

Left: A pair of 1st SOS A-1s escorts a 19th TASS OV-10 as part of the SARTF force taking part in a rescue in Laos in October 1972.

Below: In the late 1960s the O-1 FACs were replaced by the much faster and armed OV-10A Bronco. Beginning in 1970, OV-10 FACs equipped with the Pave Penny/Pave Nail designator pod were incorporated into the SAR team. Assigned to the 23rd TASS, 56th SOW, the Pave Nail OV-10s provided much greater accuracy when attacking North Vietnamese anti-aircraft positions.

the next 12 days, bombing every major target in Hanoi and Haiphong. The desired results were achieved when the North Vietnamese went back to the bargaining table in earnest. The cost had been high – 15 B-52s, two F-111As, and five other Air Force and Navy aircraft were shot down during the Linebacker II campaign. Ten of the B-52s were downed over North Vietnam, with no rescues. Many of the aircraft lost during Linebacker II went down in areas that were simply too dangerous for any type of rescue attempt, and any aircrew member who survived the shoot-down became a PoW or was listed as missing. In comparison, the other five B-52s hit eventually made it out of North Vietnam before crashing in the jungles of Laos. Members of the 3rd ARRG recovered 30 of the 31airmen, but four were mortally wounded and did not recover.

Interestingly, the rescue forces in Southeast Asia were drastically reduced again immediately prior to the Linebacker II operations. On 30 November, the 37th ARRS, an HH-53 unit at Da Nang, was inactivated completely. Five of its 'Jolly Green' helicopters were transferred to the 40th ARRS at NKP. On 15 December, just three days before the beginning of the LB II operations, the 40th lost two of its HH-53s because the unit was 'over-strength'. When the war in Vietnam ended on 15 January 1973, 3rd ARRG total assets were 11 HH-53Cs, 14 HH-43Fs, and six HC-130P tankers assigned to the 56th ARRS at Korat.

The war continued in both Laos and Cambodia for several months, with a Laotian ceasefire going into effect in February 1973. The last aircrew recoveries by the 3rd ARRG came on 3 January 1973, when a B-52 went down after being hit by a SAM near Vinh. On 4 May 1973, a 3rd ARRG HH-53 pulled First Lieutenant T. L. Dickens from the Cambodian jungle. There were no more rescues in Southeast Asia until 1975.

On 14 March 1975, the North Vietnamese violated all portions of the Paris Peace Accords and opened a massive offensive against South Vietnam. Without American air support, the outmanned ARVN troops were quickly over-run. It became obvious that South Vietnam would soon fall. MACV Headquarters, the 7th AF, PACAF and the Joint Chiefs implemented the last major rescue effort of the war – Operation Frequent Wind, which called for a helicopter evacuation of all US personnel, families and 'friends' remaining in South Vietnam.

On 19 April, additional HH-53Cs were moved to U-Tapao AB, Thailand, assigned to the 56th Special Operations Wing based at NKP. These 'Jolly Greens' would not be on the runway at NKP when Frequent Wind began: on 20 April, two of the ARRS HH-53Cs and eight CH-53 'Knife' helicopters from the 21st SOS flew to the USS *Midway*, which was standing by in the South China Sea.

Frequent Wind

When the order to execute Frequent Wind came on 29 April, the HH-53s and CH-53s left the *Midway* and headed for Saigon. Escorted by Marine Cobra gunship helicopters, the first three rescue helicopters landed on the roof of the Defense Attaché's complex of the American Embassy in Saigon. Loaded to almost twice their capacity, the helicopters left Saigon and flew directly back to the *Midway* – followed by a hail of NVA gunfire and SAMs.

Several more flights by Air Force and Marine H-53s continued the air evacuation throughout the day and into the night. By 01.45, the helicopters had evacuated 6,619 people from the roof of the embassy compound, and President Nixon ordered that only US nationals be evacuated from that point. At 07.30 on 29 April 1975, the last remaining Marine guards climbed aboard SWIFT 22, a Marine CH-53, and lifted off. Operation Frequent Wind and US involvement in Vietnam was terminated.

Between 1962 and 1975, Air Rescue Service units recovered 4,170 personnel, including 2,780 combat saves throughout Southeast Asia. Against this was the loss of 10 HH-43s, 24 HH-3Es, and 11 HH-53/CH-53 helicopters. Was it worth it? Every man in the ARS will answer with a resounding, "Yes, sir!"

Larry Davis

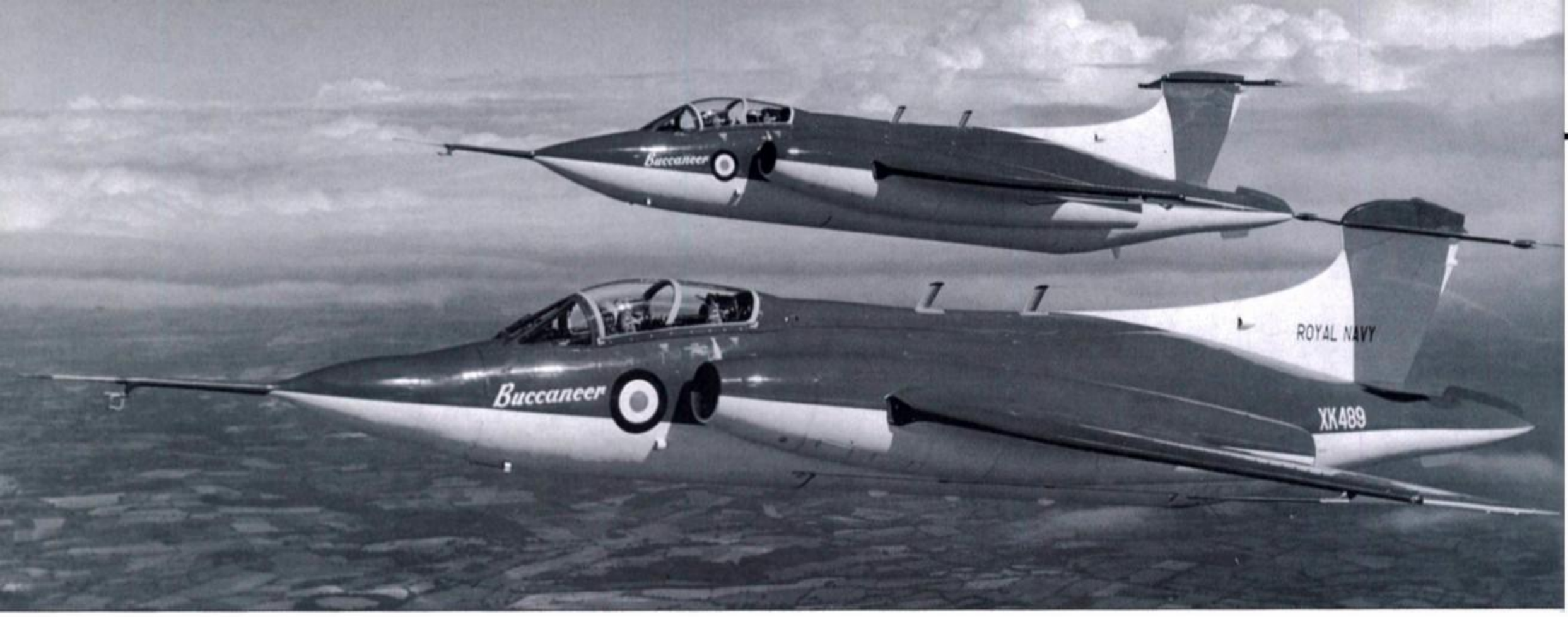
Above: The A-1's SANDY mission was taken over by the LTV A-7D assigned to the Udorn-based 3rd TFS in November 1972. The near-sonic speed was both a help and a hindrance: the A-7 could reach a rescue scene much quicker, but it also burned much more fuel, meaning that many more A-7s were required to provide cover while other aircraft were away on the tanker.

Right: Another A-7D unit sent to Southeast Asia as part of Constant Guard VI was the 354th TFW from Myrtle Beach AFB, South Carolina. This unit also flew SANDY missions.

Blackburn Buccaneer

Developed as a low-level nuclear striker for the Royal Navy, the Buccaneer was to find even greater success in the hands of the RAF, a service which had continually rejected it during its early life.

The Blackburn Buccaneer strikes at 'zero' feet beneath an enemy's radar defences



The second (XK487 – background) and fourth (XK489 – foreground) prototype Buccaneers are seen on their way to the Farnborough air show in September 1960. XK489 was the first aircraft completed with the bulged and lengthened nosecone which would house the Blue Parrot radar. In addition to its new-shape nose, XK489 was the first to be completed with a bomb door, folding wings and an arrester hook. Although the development batch consisted of 20 aircraft, only the first three can be considered as true prototypes, whereas the remainder were pre-production aircraft incorporating ever greater amounts of operational equipment. Of the 20 aircraft, nine were intended for manufacturer's trials, five for Ministry of Aviation clearance and the final six for the Navy's intensive flying trials unit.

A magazine advertisement run by Blackburn Aircraft in the summer of 1959 claimed "The NA.39 is ahead". Going on to extol the virtues of area rule applied to aircraft designed for low-level, high-speed flying ("it allows the airflow gradually to contract and expand over the total cross-section of the aircraft"), the text clearly indicated that the company's new naval strike aircraft was destined to be a winner.

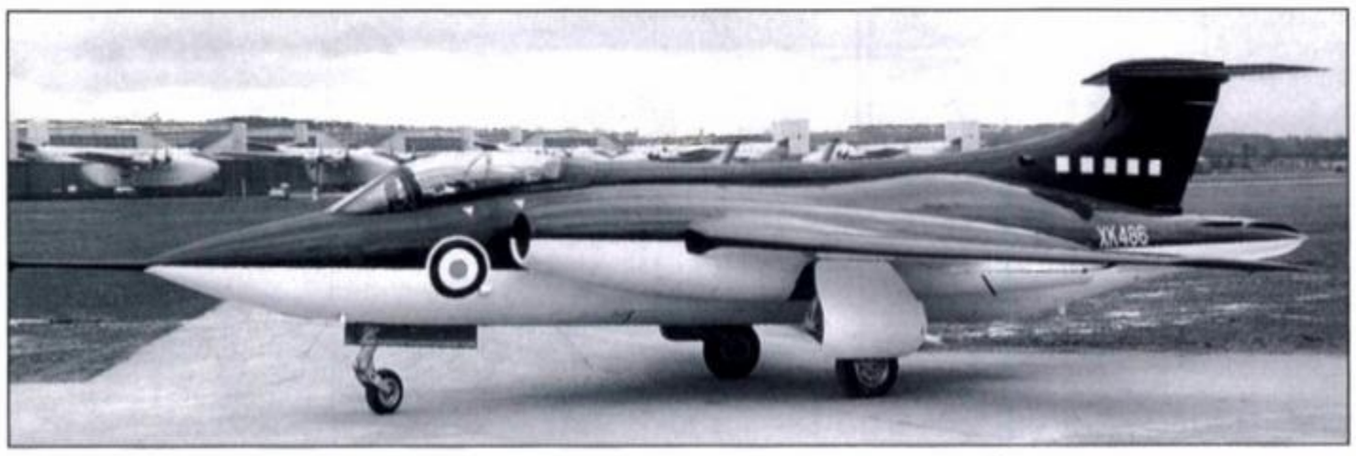
History will probably record a split verdict on the success of the Buccaneer (as the fledgling aircraft was named on 26 August 1960). Technically, the design was an undoubted success; that the aircraft was still in service over 30 years later is adequate testimony. From the production and sales point of view, however, the situation was less satisfactory. The specialised nature of the design, the secrecy which precluded its promotion abroad in the early years and the need to get the government's approval for any possible export sales kept the production total low – 193 for the UK and 16 for South Africa (with a follow-on batch refused by the British government of the day). The upper echelons of the RAF from the mid-1950s and through the 1960s turned a permanently blind eye towards the type as a potential Canberra replacement, being seduced by ever more complex supersonic designs which were eventually to crystallise as TSR.2. This short-sighted attitude led to the Buccaneer being labelled, perhaps unfairly, as 'the aircraft that the Royal Air Force did not want'. Paradoxically, after giving excellent service in the Fleet Air Arm, the Buccaneer went on to give outstanding service in the RAF over a period of 25 years, culminating in playing a crucial role in a major war.

The NA.39 was, indeed, ahead of its time. Conceived in the mid-1950s, it was designed to a specific Royal Navy requirement for a carrier-based aircraft capable of countering the growing capabilities of the Soviet navy, and in particular the new cruisers of the 17,000-ton 'Sverdlov' class. Equipped with heavy gun armament – both offensive and defensive – the 'Sverdlovs' were evidence of a new Soviet determination to expand that country's influence around the world. At the time, the Royal Navy still had a small force of aircraft-carriers, equipped primarily with British aircraft designed to British requirements. The NA.39 was intended as a low-level, high-speed (yet subsonic) attack aircraft, capable of approaching the target 'under the radar' to attack with conventional or nuclear weapons. This was before the era of serious anti-ship guided weapons, and attacks against 'Sverdlov' cruisers were envisaged with a nuclear weapon, using a toss delivery.

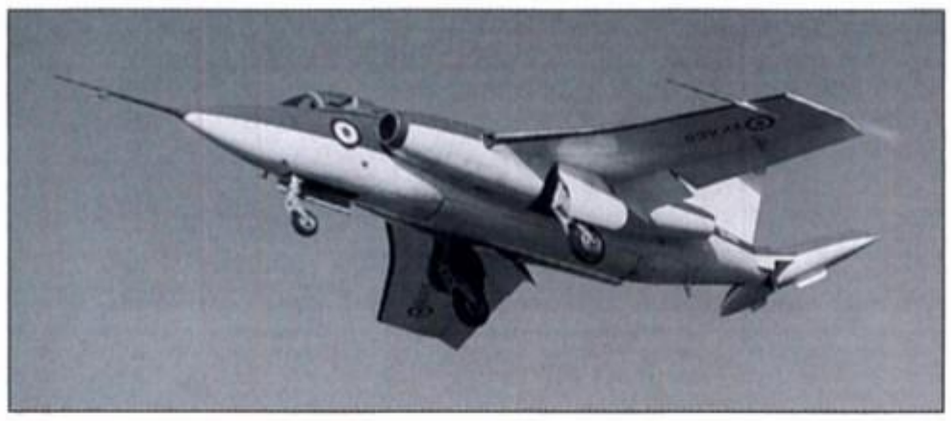
Genesis

It was in the summer of 1953 that Naval Staff Requirement 39 was drafted and circulated to a number of British manufacturers (this in an era when there were still numerous independent companies). Blackburn, whose current product line featured nothing more technologically advanced than the B.101 Beverley military transport and its civilian equivalent the B.100 Universal Freighter, was one of at least a dozen companies which decided to tender. The requirement was a taxing one, intended to give the Fleet Air Arm an aircraft capable of exploiting the gap 'under the radar' and of penetrating enemy defences at low level.

Principal requirements were: the ability to fly long range at medium or high level, descending to ultra-low level outside enemy radar detection range; to be capable of detecting and attacking enemy ships or land targets, using conventional or nuclear weapons; to carry a weapons load of 4,000 lb (1814 kg); to be compatible with Royal Navy carrier decks and (more restrictively) carrier deck lifts, which imposed maximum dimensions of the aircraft when 'folded' of a 51-ft (15.5-m) fuselage length and a 20-ft (6.1-m) span (i.e., to fit on a standard 54-ft/16.5-m lift); to be compatible with – and stressed for – regular use with carrier steam catapult launch and arrester gear; to have a take-off weight of 40,000 lb (18144 kg) – with a maximum of 45,000 lb (20412 kg) – and landing weight of up to 35,000 lb (15876 kg); and, to have the ability to function as an inflight-refuelling tanker (an example of a far-sighted



The first Buccaneer, XK486, was taken to RAE Bedford for its first flight on 30 April 1958 as the company runway at Holme-on-Spalding Moor was considered too short. The aircraft is seen above rolled out at the Brough factory which was primarily engaged in Beverley production at the time.



requirement). Although not explicit in the specification, there was a need for a weapons bay capable of employment at high speed.

Few more technically challenging requirements had been issued in the immediate post-war years. While the radius of action and required warload dictated a large aircraft with good internal tankage and an internal weapons bay, the maximum all-up weight and overall 'folded' dimensions were obvious limiting factors. (As an aside, the only other Western aircraft built to similar requirements was the Grumman A2F-1, designed in response to US Navy Type Specification 149 of 1955. This aircraft became the highly-successful A-6 Intruder, which was built in numbers far exceeding those of the Buccaneer – although it was never exported.)

The resulting aircraft would clearly need to be twin-engined, and the Armstrong Siddeley Sapphire Sa.7 was an early favourite to be the powerplant. The design took shape around two Sapphires, but de Havilland's proposal for a scaled-down version of its Gyron turbojet, the PS.43 Gyron Junior (or Bristol Siddeley Gyron Junior Mk 101, as the production engine was later styled), took favour in 1954. While the Sapphire's 11,000 lb (48.92 kN) of thrust gave better performance, it would have led to an aircraft too heavy. The Gyron Junior's weight and its 8,000 lb (35.58 kN) of thrust proved better matched to Blackburn's proposal, which proceeded under the designation B.103.

Blown surfaces

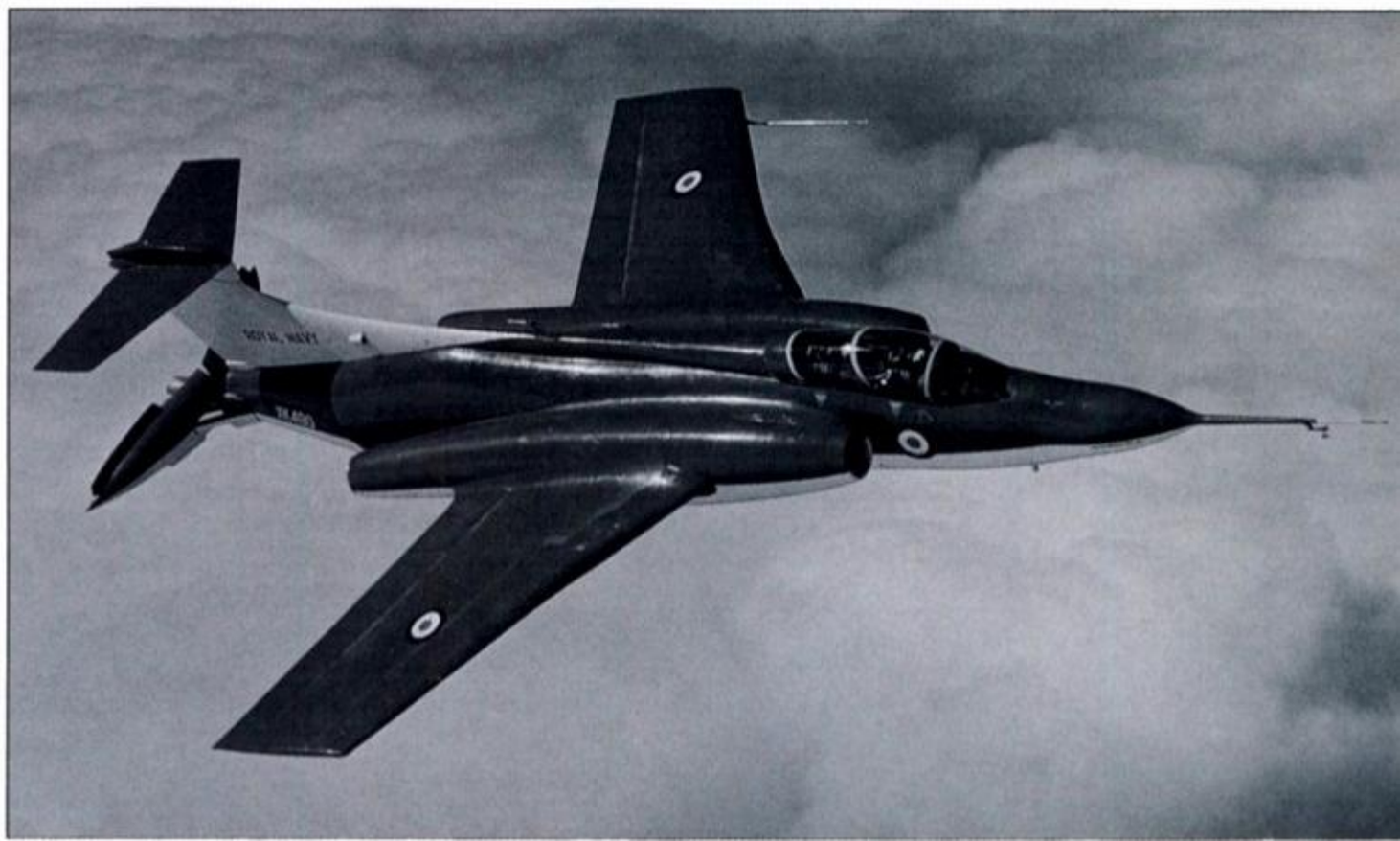
Given the weight of the proposed aircraft and the dimensions of Royal Navy carrier decks, the landing requirement proved difficult to meet. In 1954 Blackburn became aware of test results (mainly from the USA) of the beneficial effects of 'flap blowing' – blowing engine bleed air over wing flaps to re-energise the airflow and to improve lift. Although this technique appeared to offer worthwhile performance gains, the technology was very new and untried, except on experimental aircraft. To Blackburn's design team, though, the potential was too good to miss and – to their eternal credit – they adopted boundary layer control (BLC) into their proposal. Some 10 per cent of the mass flow of each engine was to be exhausted through ducts along the leading edge of the wing and tailplane, and over the wing trailing edge, ahead of the flaps and ailerons. With drooped ailerons, the wing effectively had full-span flaps, and boundary layer control could reduce landing speed by 17 kt (19 mph; 31 km/h), with the BLC blow cutting in automatically when surface extension exceeded 10°. The same system also provided hot air for airframe de-icing – an elegant solution to the requirement for anti-icing. Design challenges with the flap blow remained, though, not the least being the pitch change which would become evident on flap selection. For this, a tailplane flap was incorporated. The boldness of this decision to incorporate BLC – taken in principle before even the final choice of the Gyron Junior as the definitive engine – cannot be overestimated.

A second major design challenge concerned weapons carriage. While underwing pylons were to be fitted, the design envisaged the provision of an internal bomb bay, capable of accommodating four 1,000-lb bombs (in two pairs, side-by-side), a single nuclear weapon or the envisaged anti-shipping homing bomb with the unlikely code-name of Green Cheese. Conventional hinged bomb bay doors, and stores suspended from the top of the bay, were discarded as being unsuitable for release at the high speeds envisaged. The solution adopted was to fit a 180° rotating bomb bay door, hydraulically activated, in which the weapons were carried on the inside of the door itself. This gave an effectively shallow bomb bay (with its attendant aerodynamic advantages) when open, and was usable with minimal trim changes at any speed. It also made for easier loading of weapons, while a 90° position gave ground crews access for servicing. The rotating bomb bay proved itself in many years of service. Early plans existed for a pair of ADEN cannon to be fitted in the bay, to give the aircraft an enhanced ground-attack capability, but the aircraft was destined to remain gunless. The bay could also fit a reconnaissance camera pack, or a second additional tank of 440-Imp gal (2000-litre) capacity. At air shows – particularly in the Buccaneer's later navy years – the bay was often rotated to display the legend 'FLY NAVY' in large, Dayglo letters.

Above: XK490 makes a low, slow pass along Farnborough's runway in 1959 as a Folland Gnat F.Mk 1 turns on to the runway for its display. The month following the show, '490 became the first NA.39 to be lost.

Above left: XK488 was the third prototype, and spent much of its test career on engine trials with Bristol at Filton or de Havilland at Hatfield. It was the first to be painted in the standard Royal Navy camouflage. Today it is proudly displayed at the entrance of the Fleet Air Arm Museum at Yeovilton.

These two views of XK490 highlight the area-rule bulged rear fuselage of the B.103/NA.39 design. The split airbrake concept had been used by several aircraft before, but in the Buccaneer found its best-known expression. The brakes were considerably modified during development to avoid undesirable trim changes. Strakes of varying sizes were added above and below the petals until a suitable configuration was discovered.



Pre-production

Above: Blackburn used this photograph of six pre-production NA.39s to publicise the naming of the aircraft as the Buccaneer in August 1960. At the far end of the line are the first two aircraft. XK523 (third from end) was used for early bomb separation trials, and was notable for being fitted with inward-facing cameras in wingtip fairings.

Above right: XK524 was an important aircraft as it was the first to incorporate a host of structural modifications which would appear on the production aircraft. Seen here undertaking trials of the underwing 'slipper' tanks, the aircraft is fitted with wingtip 'bonkers'. These were small charges fired by command from the cockpit and employed to induce flutter in the wing to prove the damping effect. 'Bonkers' were employed when testing flutter resistance with differing wing stores.

Following the first three 'flying shells', Blackburn produced in rapid order 17 further pre-production aircraft, known as NA.39s and first flying in 1959/61. These were used on a variety of trials to hasten the service entry of the type. XK526 was the first aircraft completed to full S.Mk 1 standard, taking to the air on 29 August 1960. The final six NA.39s were delivered to the Navy for intensive flying trials.

It was while the B.103 design was being finalised that the principles of area ruling became available, decreeing that the cross-sectional area of an aircraft be kept constant. These principles were enthusiastically adopted, and the design subtly was altered to include some waisting and the now-familiar 'area rule' bulges in the rear fuselage behind the wing trailing edge. Although their inclusion was on aerodynamic grounds, both to delay the drag rise at speeds close to Mach 1 and to improve the flying qualities at high speed and low level, they had the added advantage of offering additional stowage space for avionics.

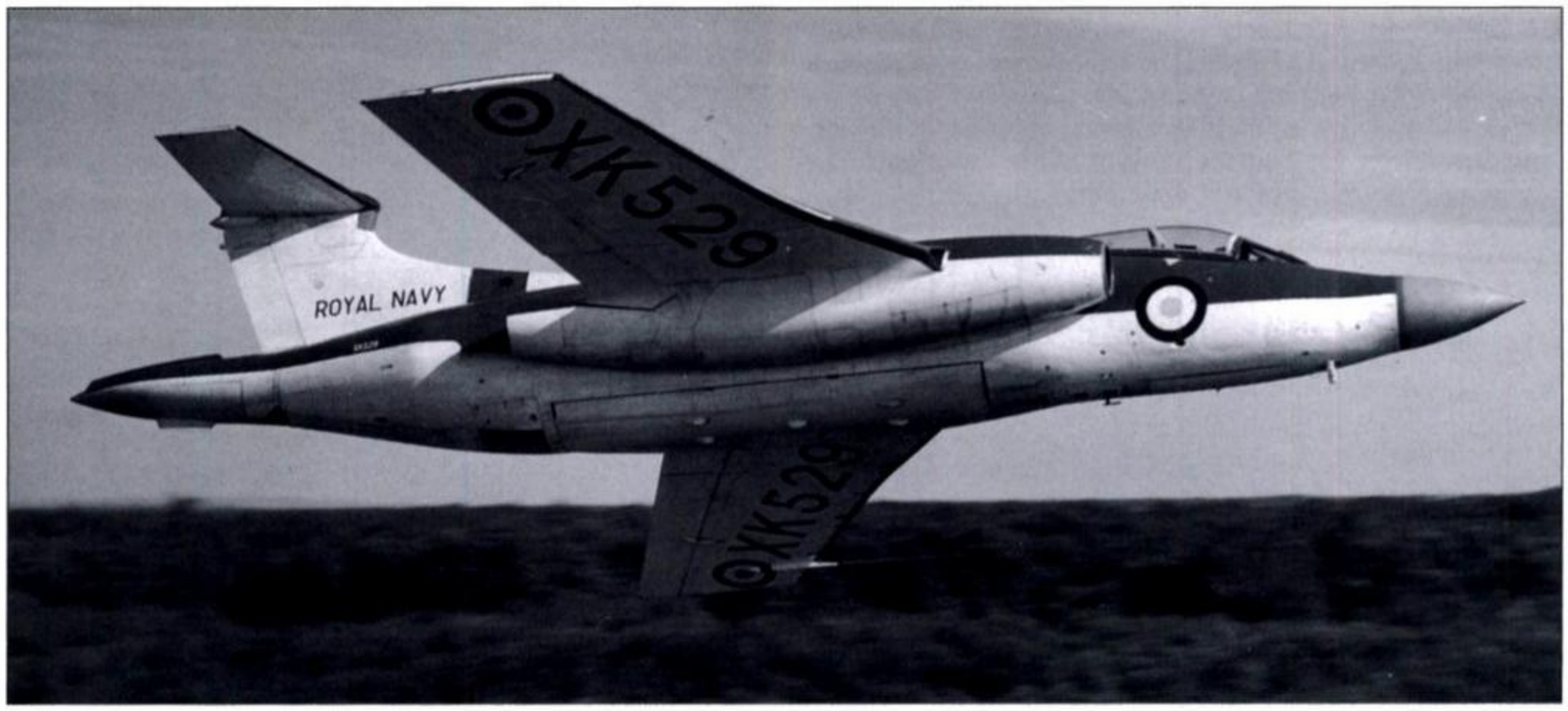
The problem of meeting the carrier deck lift overall dimensions was solved in a novel manner. Like most naval aircraft, the B.103's wings were hinged at 45 per cent span, to fold through around 120°. The nose cone, which would house a radar, was also hinged on its port side, to 'fold back and point aft', again in pursuance of the all-important (on a carrier) aim of reducing stowage space. Dive brakes were provided at the rear end of the fuselage, being massive both in size and effect, and involved the vertical splitting of the rear fuselage into two brake 'petals', moving together and operating by a crosshead with drag links incorporated at a point one-third of the distance from the break point of the fuselage. These airbrakes were highly effective in flight, particularly in providing precise control in the landing configuration, by allowing the use of high engine rpm and consequent high pressure engine bleed air. On the deck, deploying them in the 'wide open' (90°) position reduced the fuselage length by 4 ft (1.2 m) for carrier stowage.

'Built like a brick outhouse'

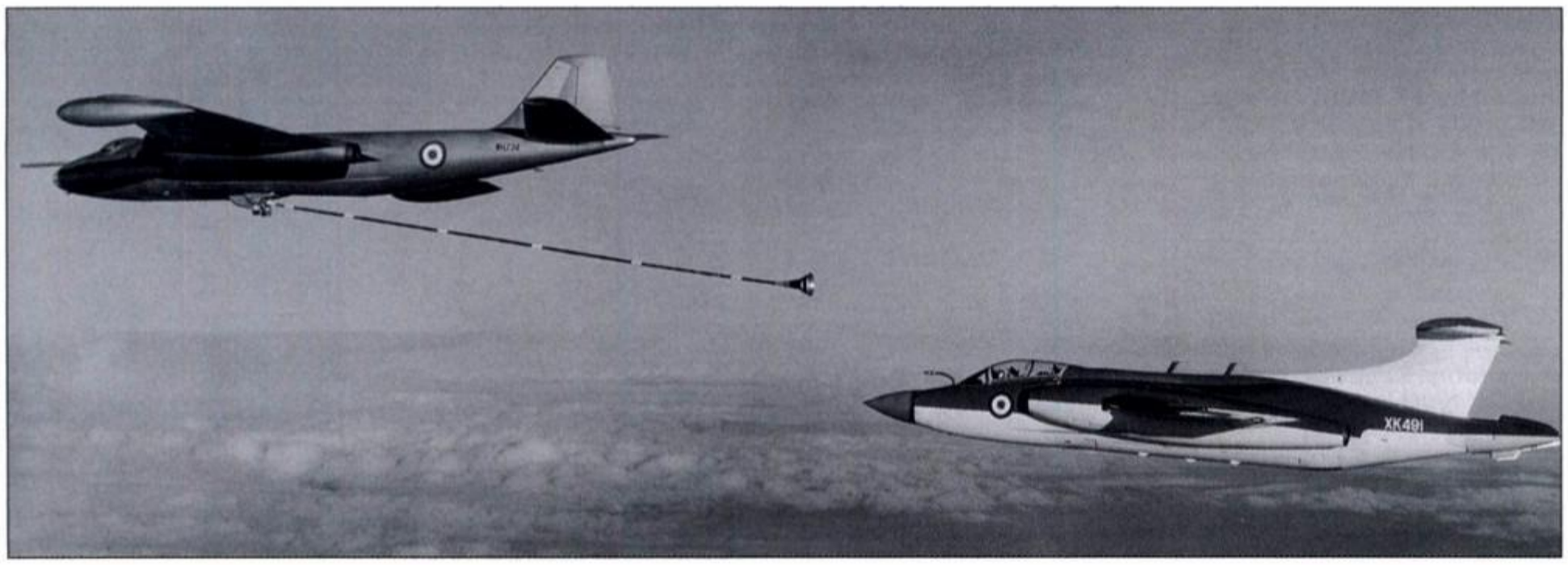
Being designed from the start for the high-speed, low-level attack role, the B.103 needed a long fatigue life in this demanding environment, with 3,000 hours being the design aim. (While this figure may not seem high – indeed, Britannia Airways would be unhappy not to get this number of hours from a Boeing 757 in a single year – it should equally not be forgotten that the RAF's V-bombers, and the Valiant in particular, suffered structural problems when reroled from the relatively undemanding high-altitude bombing role to low-level attack in the 1960s.) Most of the airframe was to be constructed of aluminium alloys, but steel was used where its strength was required, and extensive use was made of milling from the solid, using techniques recently imported from the United States. Most of the wing and tailplane featured integrally machined 'one-piece' skin and ribs, and use was made of machined forgings throughout the airframe. The aim was to give the B.103 the same structural life in its assigned role as any other naval aircraft operating in a less demanding environment.

Buccaneer pilots, both Fleet Air Arm and RAF, have extolled the virtue of their aircraft's strength over the years. One such demonstration, the story (possibly apocryphal) goes, was for a Buccaneer crew member to go up to 'any other' fighter aircraft (an F-104 Starfighter was good for the purpose), bang on the fuselage with his fist and walk away muttering, "It'll never last." This confidence was well justified by the design, but must be seen against the context of the airframe structural failures of 1979/80, as related later in the Buccaneer story.

Blackburn had frozen the B.103 design by the summer of 1954, but discussions with the Ministry continued in earnest and only with the awarding of a development contract in July 1955 was it announced that the company's submission had been selected to meet NA.39. That an unusual degree of seriousness had been attached to the project was underlined by the ordering of 20 development aircraft, rather than the 'penny packet' numbers normally



XK529 was the 13th aircraft built, and was always regarded as a 'jinxed' aircraft. Blackburn called it aircraft 12A, but it became something of a 'hangar queen'. Its career was short, ending in a tragic catapult launch accident while operating from HMS Hermes on 31 August 1961. The aircraft suffered an immediate pitch-up after launch, perhaps as the result of a BLC system failure, resulting in a stall.



XK491 was the first Buccaneer to undertake refuelling trials, initially with an RAF Valiant and then with Flight Refuelling Ltd's Canberra, seen here. The first probe for the Buccaneer was a curved, retractable unit, but this posed insurmountable problems in terms of airflow around the aircraft's nose. Despite one attempt at a redesign, the retractable probe was abandoned completely in favour of the characteristic bolt-on probe. This aircraft, the sixth, also introduced a small lengthening of the forward fuselage, which improved the crew's view slightly by placing the cockpit further ahead of the engine intakes.

associated with British aircraft of the time. Blackburn also adopted the new 'weapon system' approach, where the prime contractor was responsible for both the aircraft and integration of its systems and weapons. The award of the contract meant that Blackburn was back in its traditional business of building carrierborne aircraft, which it had lost with the termination of Firebrand production in 1947. And, while the B.103 was externally of fairly conventional layout, its design incorporated features which were, for its day, both novel in concept and challenging at an engineering level. For Blackburn, the transition from developing and producing the lovely-but-lumbering Beverley to the high-tech B.103 was to be a dramatic one.

Construction of the 20 development aircraft was undertaken at the company's Brough factory, where both a great increase in the number of design staff and a large investment in machine tools – mainly from the USA – were required. The decision had already been taken that the runway at Brough was inadequate for the NA.39, and that the company's test airfield at Holme on Spalding Moor (HoSM) would be used for the test programme. The Ministry decreed, though, that the first flight should be made from RAE Bedford. The first three aircraft of the batch (XK486-488) were to be 'pure' prototypes for the testing of basic systems and flying characteristics. From the fourth aircraft, 'navalised' features and provision for weapons were to be incorporated, while the ninth aircraft and onwards were to receive the full systems. Viewed externally, the nose profile was altered from the fourth aircraft, the extended front fuselage and nose cone now having provision for radar.

A considerable degree of secrecy

The NA.39 programme was shrouded in substantial secrecy. Following ground engine runs at Brough in March 1958, XK486 was partially dismantled and transported, wingless, by road to Bedford. To confuse the enemy – but probably not any number of spotters who noted it en route – the aircraft was covered by tarpaulin and shrouded from view, looking for all the world like a beached whale. Painted gloss blue on the upper surfaces and white underneath, XK486 was apparently given non-standard-sized roundels, again to confuse. Even so, as soon as the first side-view photos of the aircraft became available, those 'in the know' started to estimate dimensions, scaling the photos against known components such as wheels, and came up with figures which later proved almost exactly correct.

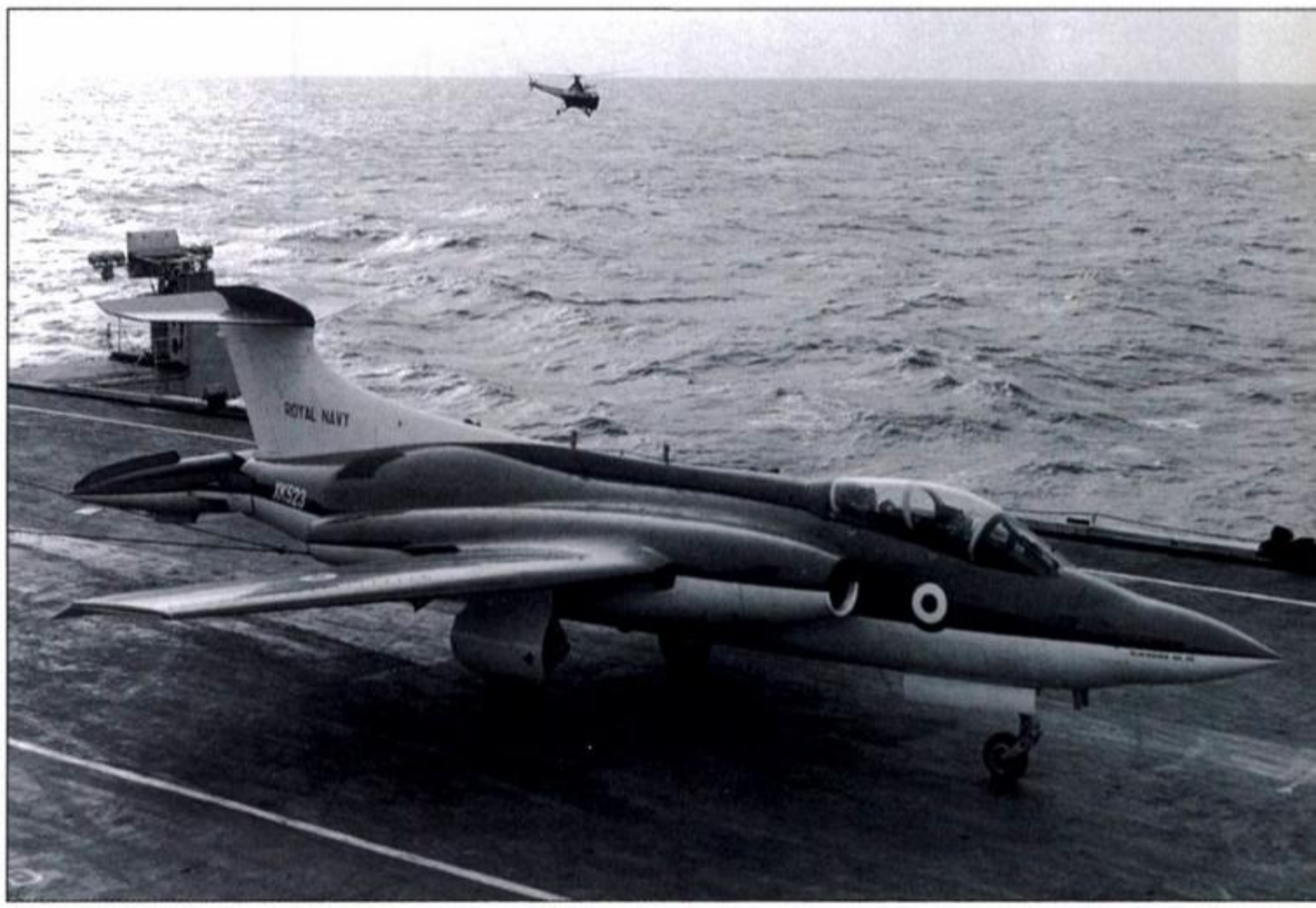
Initial taxi trials at Bedford got under way in April 1958, and the first flight took place on 30 April with Derek Whitehead in the front seat and head of flight test B. J. Watson in the rear. The flap blowing system was not used on this flight, which lasted 39 minutes, but the massive airbrakes were deployed on landing. During the following three months of test flying at Bedford, the boundary layer control system was tested and found to be as successful as its designers had hoped. Finally, on 9 July 1958, Derek Whitehead flew XK486 to HoSM, to continue its test programme at the company airfield just 12 miles (19 km) from the Brough factory. That only 36 months had elapsed since the award of the contract was great credit to the Blackburn team which had brought the NA.39 to this point.

Public debut

The NA.39 made its first public appearance at the SBAC Show at Farnborough in September 1959, although it flew in from Boscombe Down each day to keep it away from prying eyes. In a year in which it was the only major new type present, it generated great interest.

The second (XK487) and subsequent aircraft all made their first flights from HoSM, making the journey from Brough along public roads. XK487 was considerably instrumented for flutter tests, and was used to expand the flight envelope. To underline the naval nature of the programme, and to improve safety at HoSM, arrester gear was installed at either end of the main runway, and mirror landing gear fitted. XK488 was used primarily for testing associated with the type's de Havilland Gyron Junior powerplants, carrying out most of the flying from Hatfield and Filton. This

XK523 and XK489 flew the Buccaneer's first carrier deck landings in January 1960. XK523 was the first to reach HMS Victorious on the 19th of the month, Blackburn test pilot Derek Whitehead flying a hookless 'touch and go' approach (left) prior to the first arrested landing (below). In the background is a Westland Dragonfly plane-guard helicopter.

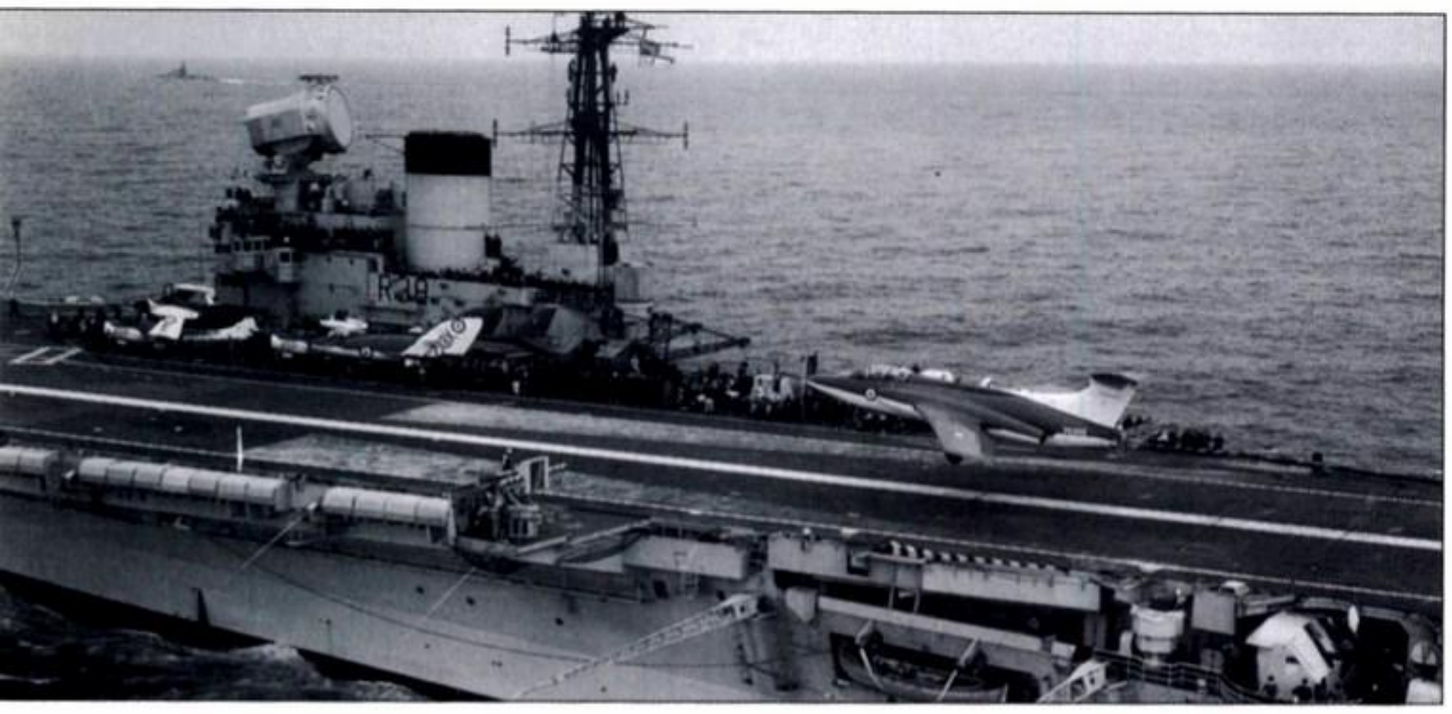


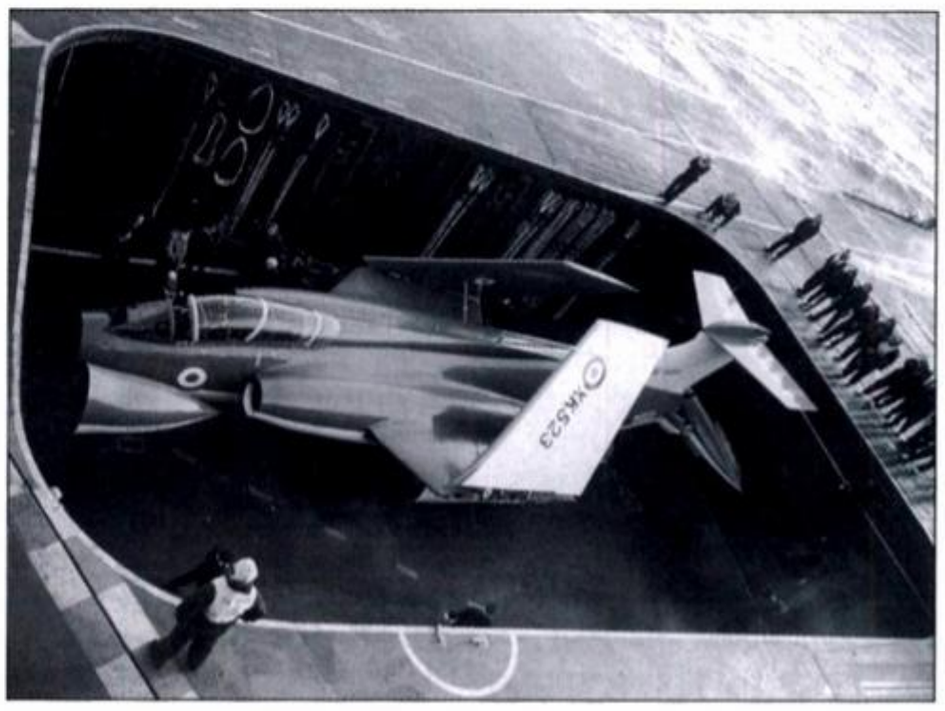
Carrier trials

Delayed by investigations into the loss of XK490, carrier trials eventually got under way in January 1960, XK523 being the first aircraft to land on a carrier (*Victorious*), where it was joined by XK489. The first series of trials resulted in generally successful flights. Many further carrier trials series were undertaken prior to the aircraft's entry into front-line service. A number of these trials were aimed at clearing the aircraft for deck operations with various stores, and were often tested on the dummy deck at Bedford before the trials proceeded to sea.

Below: XK489 perfoms a 'touch and go' on Victorious *during the initial trials of January 1960. The weather was often appalling.*

Right: Later in 1960 XK489 was aboard Ark Royal *for another series of trials. Catapult launches could often be marginal affairs.*





Above right: By the use of a folding radome, folding wings and splitting airbrake, the Buccaneer just squeezed on to the deck lift and hangar deck.

A well-known, yet still dramatic, photograph shows the Buccaneer's first carrier launch, XK523 throwing off the bridle while launching from* Victorious. *During launch the Gyron Junior engines were run at a temporary high jetpipe temperature to provide sufficient air for the blowing system as well as thrust.

aircraft also introduced the more standard Fleet Air Arm camouflage scheme of dark sea grey upper surfaces and white undersides, which was to become usual for succeeding aircraft of the development batch until the decision to 'go white'.

XK489 was the first aircraft with navalised features (folding wings, arrester hook, etc.), a bomb door and provision for stores carriage. It made its first flight on 31 January 1959 and later that year migrated south to A&AEE Boscombe Down and to RAE Bedford, to fly catapult launches and arrested landings from the 'carrier deck' there. It was during 1959 that the rotating bomb bay door was first tested in flight, proving to exhibit satisfactory characteristics when opened at all speeds. XK490 took part in handling and hot-weather trials, the latter in Malta. The sixth and seventh aircraft, XK491 and XK523 (blackout blocks were still very much in use at the time), were the first with a revised electrical system and an autopilot.

A closer public scrutiny of the type was made possible when XK490 appeared at the Le Bourget show in June 1959, at a time when the overall dimensions were finally released to a none-too-surprised world.

Buccaneer goes to sea

Carrier trials were due to start in October 1959, using XK489 and XK523, operating from HMS *Victorious*. In the event, they had to be postponed when XK490 crashed, inverted, into the New Forest on 12 October 1959, on an evaluation flight from Boscombe Down with an American pilot and a Blackburn test observer. Investigations deduced that the cause was a stall at low speed, at an altitude too low for recovery. Both crew ejected from the inverted aircraft, but neither survived. It was thus a snowy January 1960 when carrier trials first got under way in Lyme Bay. The task of making the first deck landing went to Derek Whitehead, who landed XK523 uneventfully on HMS *Victorious* at the completion of a flight from HoSM. XK489 joined it aboard two days later, for a series of trials which were to last a week, often in miserable weather conditions. Launches were made at increasing weights, with a total of 31 flights being achieved. No major problems were encountered, although some changes to both arrester hook and undercarriage were deemed necessary as a result. It was the first opportunity to check the NA.39's compatibility with a Royal Navy carrier, the refuelling and servicing methods employed and the all-important matter of being able to fit on a standard deck lift.

The eighth NA.39 was built to a new standard, incorporating a number of changes found necessary or desirable earlier in the programme. As a result, XK524 did not make its first flight until 4 April 1960, some eight months after XK523. While visually little different from its predecessors, XK524 incorporated numerous structural modifications and changes to cockpit layout and instrumentation. As such, it was effectively the first NA.39 built to production standards; as a result of these changes, some of the qualification trials had to be repeated. XK525, which followed into the air on 15 July 1960, was the first with the complete navigation and weapon system. XK526-528 had joined the

Above: An unmarked S.Mk 1 rests aboard a carrier during trials. The fin/tailplane bullet fairing was adopted to cure some airflow separation in this area, which in turn caused 'snaking' at high speed.

Above left: XK536, the last of the pre-production NA.39s, prepares to launch from* Hermes *in May 1962. Among the important tasks of this trials series, undertaken alongside XK530, was carrier clearance for the Red Beard nuclear bomb.

test programme by the end of 1960, all three spending time at A&AEE Boscombe Down in an effort to meet the planned date for Controller Aircraft (CA) Release of April 1961.

The aircraft which had thus far been known only as the NA.39 was finally (and formally) named the Buccaneer on 26 August 1960, a name that was highly appropriate for a naval aircraft, as well as perpetuating the British manufacturers' delight in alliterative names. The production aircraft were thus designated Buccaneer S.Mk 1, the 'S' indicating strike, i.e., nuclear capability.

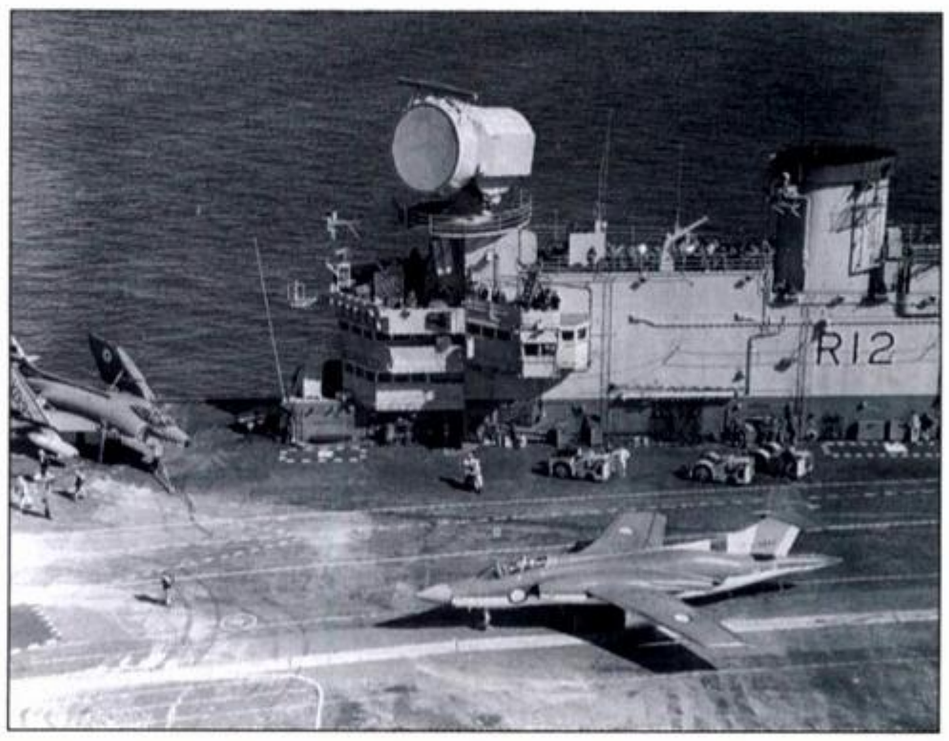
A second crash was then suffered by the programme. G. R. 'Sailor' Parker was flying XK486 on autopilot trials on 5 October 1960 when he suffered an instrument malfunction and the aircraft started to roll. Parker and his observer managed to eject safely, but the Buccaneer crashed at Little Weighton, not far from Brough; the cause was found to be a failure of the artificial horizon. This crash had no major impact on Blackburn's test schedules, which were now close to achieving CA Release.

Dispersed flight tests

Not all flying activity was centred on HoSM. Boscombe Down and its test pilots and engineers were involved in various assessment programmes, while other Buccaneers were flying weapons trials from West Freugh, on the west coast of Scotland. CA Release was achieved in July 1961, at which point the Royal Navy's Intensive Flying Trials Unit (IFTU), No. 700Z Flight, was able to receive its first Buccaneers, and to take up its task of assessing the operational role of the Buccaneer and formulating operating procedures for squadron service. It was during deck trials from HMS *Hermes* that XK529 crashed on 31 August 1961 in Lyme Bay, with the loss of both crew, the aircraft involved being operated by A&AEE Boscombe Down's 'C' Squadron.

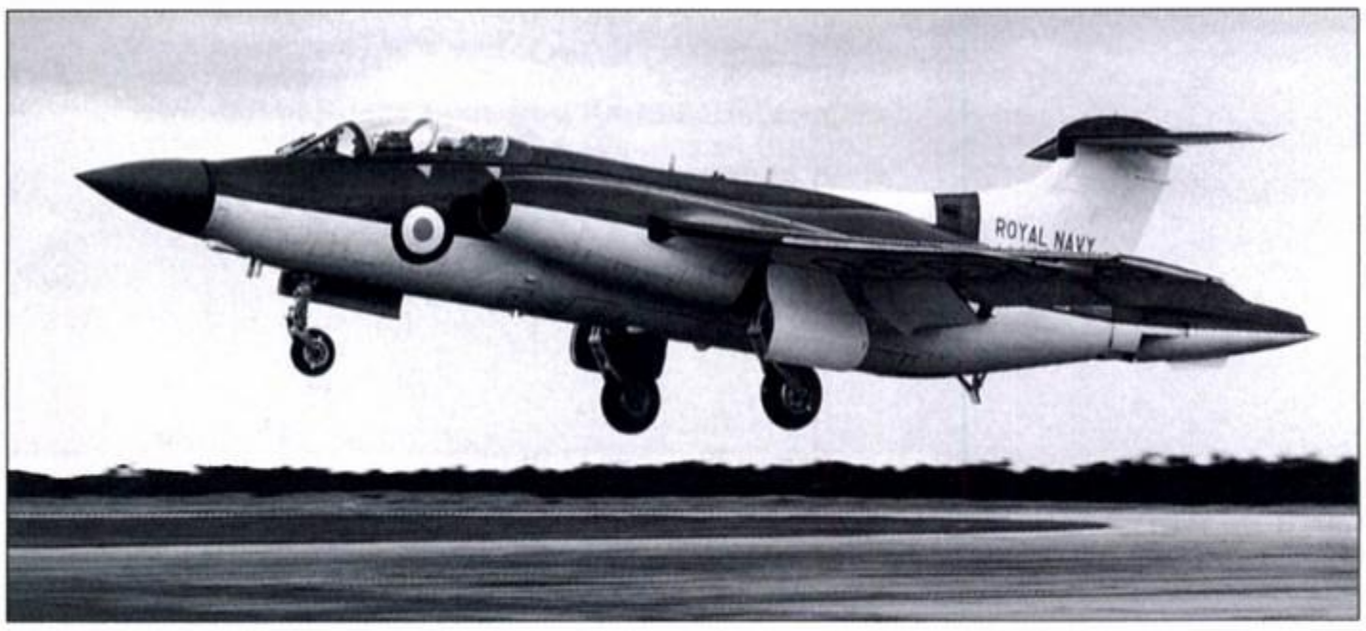
All 20 of the development batch aircraft had flown by the end of 1961, the final six incorporating virtually all of the features of production aircraft, and activity on the HoSM flight line continued at a high level. In general – and despite the loss of three aircraft – relatively few major problems had been experienced, and the aircraft which No. 700Z Flight were operating were not significantly different from the design originally advanced by Blackburn, before the first flight of XK486. The fitting of a fin/tailplane bullet fairing, which cured some airflow problems, was an obvious external change; other, less obvious, changes concerned the wing-fold mechanism, the engines and control surface gearing.

There is a persistent rumour – or should that be myth? – that the US Navy's Grumman A2F (later A-6) Intruder owes some of its design origin to the Buccaneer. It is a fact that the Buccaneer and the Intruder qualify as the West's only purpose-built jet carrierborne low-level strike/attack designs to see service. It is equally true that, in 1957, an American delegation did visit Brough, to receive detailed briefings on the NA.39, the reason being that the British programme was receiving US Mutual Weapons Development Program (MWDP) funding, which gave the US overseeing rights. Indeed, a programme review completed by the Americans in February 1957 indicated general approval, although noted that the type would prove underpowered. Perhaps Blackburn had thoughts that the NA.39 might achieve export sales success with the US Navy, as the Canberra (as the B-57) had with the USAF. The US Navy, though, decided to go its own way, and the Intruder design as it emerged represented a somewhat different approach (low-sweep wing, jet deflection, no boundary layer control) to a similar requirement. Any direct 'Blackburn influence' on the Intruder is thus difficult to see. Against this, the US



XK530 is seen aboard* Hermes *during the 28 to 31 August 1961 trials, which were cut short by the loss of XK529. This tragic launch accident resulted in the drowning of the crew after the cockpit filled too quickly with water. In the wake of the accident, it was determined that the crew stood little chance of escaping with the standard canopy procedures, resulting in the development of an MDC (miniature detonating cord) canopy for the Buccaneer which allowed through-the-canopy ejections.

Seen here landing on* Hermes *in May 1962, XK530 was one of the two aircraft involved in clearing Red Beard nuclear bomb carriage from carriers. After a series of trials on the dummy deck at Bedford, '530 moved to* Hermes *to make a series of hooked landings and launches with an instrumented bomb shape. Red Beard was the primary armament of the Buccaneer and, indeed, the whole aircraft had effectively been designed around its portly shape.



The first Buccaneer unit, No. 700Z Flight, formed on 7 March 1961, although it was not to gain any aircraft for some time. Blackburn dispatched hard-working test aircraft XK530 to Lossiemouth to attend the inauguration ceremony for the new unit. It is seen here landing at the Scottish naval air station, so beginning an association between the base and the type that would last for the next 33 years, albeit with a gap of a decade. XK531 and XK532 were to be the first aircraft delivered to the unit, with XK530 returning to its trials work after this ceremonial visit.

certainly contributed in kind in the Buccaneer development programme, providing data analysis equipment along with an agreement to use NACA wind tunnel facilities at Langley, Virginia.

No. 700Z Flight had been commissioned at Lossiemouth (HMS *Fulmar*) on 7 March 1961, with Lieutenant Commander A. J. Leahy as boss of the Intensive Flying Trials Unit (IFTU); he was ex-CO of No. 803 Squadron with Scimitars, and earlier leader of No. 738 Squadron, whose five red Sea Hawks made such an impression at Farnborough 1957. The job of the Flight was put simply by Commander Leahy at the time – "to get in as many hours with the Buccaneer as possible", with a target of 40 sorties a month. Lossiemouth as a base had the dual advantages of good weather and proximity to the Scottish military low-level routes and weapons ranges, which gave the Buccaneers the opportunity to work up the low-level tactics for which the type was designed. The first assigned aircraft were not Buccaneers; two Meteor T.Mk 7s were delivered in May, to be followed by the first of four navalised Hunter T.Mk 8s. They gave the pilots the opportunity to continue training, until the first Buccaneer S.Mk 1s were delivered in August 1961. XK533-XK536 – the final aircraft of the 20-aircraft pre-production batch – were delivered to 700Z by early 1962, to bring their complement to six, coded LM/680 through LM/685.

Above: No. 700Z Flight supplied a single aircraft for the 1961 SBAC air show at Farnborough, and then in 1962 performed a four-ship formation aerobatic display (illustrated). The unit flew a mix of its own aircraft and those loaned by 801 Squadron. Here a 700Z two-tone aircraft leads an all-white 801 machine in a 'mirror' flypast.

Right: 700Z Flight's XK531 was the first Buccaneer delivered to a Navy unit, seen here turning on to the approach over Lossiemouth harbour.

While initial deliveries were in the FAA extra dark sea grey upper surface/white undersurface scheme, XK534 was delivered in an overall white 'anti-flash' scheme with pink and pale blue roundels and pale blue lettering and serials. This scheme, which had been applied to all of 700Z's aircraft by October 1961, was similar to that adopted by the RAF's V-bombers, which were also assigned a nuclear delivery role. It subsequently became standard on Fleet Air Arm S.Mk 1s, although the extra dark sea grey/white scheme reappeared by 1964.

Prior to arrival on No. 700Z, only Lieutenant Commander Anson – the RN test pilot seconded to Blackburn for test flying – had previously flown the Buccaneer, and the other aircrew contemplated their first flight with varying degrees of anxiety. One common question was "Have you had your first fright yet?" Since there was never a production two-stick dual control Buccaneer, pilot conversion remained challenging to the end. With relatively small purchases of front-line aircraft, the Royal Navy's budgets did not allow the development of specific two-seat, twin-stick versions of operational aircraft in the same way the RAF's did.

Dual-control oddity

In fact, there was one twin-stick Buccaneer. S.Mk 2 XV344, which joined the Royal Aircraft Establishment (RAE) fleet in early 1979 after serving with the FAA, was used from 1982 on trials of a Thermal Imager Common Module Mk II/Forward-Looking Infra-Red System (TICM II FLIR), for which it was christened 'Nightbird'. For these trials, the rear cockpit was fitted with a stick giving pitch and roll control only – no rudder pedals or throttles were provided. This provision was intended to give the rear-seat safety pilot a degree of override, should the IR equipment in the front seat fail to give the correct images, to prevent a potentially dangerous situation from developing.

In August 1961, a Buccaneer S.Mk 1 from No. 700Z Squadron was demonstrated to the West German Bundesmarine at Schleswig. This was not the first, nor the last, demonstration of a Buccaneer to the Germans, but no order was ultimately forthcoming.

A Royal Navy recruiting advertisement current in the summer of 1961 depicted two Buccaneers overflying a carrier, and offered 'pay at age 20' of £949 a year for pilots and observers. The text was racy – "Fleet Air Arm Buccaneers moving at ten miles per minute above HMS *Ark Royal*. The Buccaneer is the latest aircraft ordered for the Fleet Air Arm, giving still greater speed and power to Britain's nuclear age Navy. The men who fly these

machines have a training second to none in the world, starting with a six months' course at the Britannia Naval College ...." The Navy clearly saw the Buccaneer as 'leading edge', and was keen to capitalise on it for any purpose.

For Farnborough 1962, and to mark the Buccaneer's impending entry into full squadron service (with No. 801 Squadron), 700Z worked up a four-aircraft display team. As part of this routine, the aircraft flew an energetic rolling manoeuvre. During a practice for the Farnborough show, one aircraft returned to base with damage both to the flaps and the fin, as a result of overstressing. While strong, even the Buccaneer airframe had its limits. The flight's Farnborough display made the right impression with the tax-paying public, demonstrating that the Buccaneer had arrived in service. To underline the naval tradition, Commander Leahy – referred to in contemporary accounts under the nickname 'Spiv' – and his aircrew all wore gloss black 'bone domes', decorated with a large skull and cross-bones. The aircraft they flew at Farnborough included loaned examples from No. 801 Squadron.

The flight flew the aircraft hard during the unit's short existence, the Buccaneers notching up a high sortie rate and an impressive monthly total of flying hours per aircraft. The evaluation covered all aspects of the aircraft, its engines and systems, weapons and the servicing requirements, and developed the tactics for its operational employment, including sea trials aboard HMS *Hermes*. To the credit of its designers, this period uncovered no major problems, and the engineers on the ground (and, indeed, on the deck) found the Buccaneer both serviceable and easy to turn around between flights. In particular, the aircrew noted with satisfaction that the S.Mk 1 reversed a trend: it was 10 kt (11.5 mph; 18.4 km/h) slower on carrier approach than other FAA types of its time. And the ride at low level was in a different class from that of all its contemporaries.

'Banana jet'

Many aircraft have nicknames, affectionate and derogatory; the Buccaneer has for many years been referred to as the 'banana jet'. While the origins of this appellation are less than 100 per cent clear, the name is believed to predate the naming of the NA.39 as the Buccaneer. At this time, Blackburn ran a contest in its house magazine, *The Courier*, looking for a suitable name for the new aircraft. One suggestion – which stuck, although it did not win the prize

Intensive Flying Trials Unit

While manufacturer's trials continued, the Navy received Buccaneers in May 1961 to begin exploring the operational capabilities of the type and to establish and write up the standard operational procedures. This work was hampered until the end of the year by the non-availability of radar-equipped aircraft. Flight trials tasks continued throughout 1962, including a wide variety of weapons and radar work. Another task was the provision of sufficient trained crews for the establishment of the first front-line unit, No. 801 Squadron. This training commitment was fully recognised when 700Z renumbered as 809 Squadron.

Left: The first three aircraft (LM/680-682) were delivered in a two-tone scheme with pale blue codes. Visible behind this aircraft is a refuelling pack.

Far left: Once airborne, the Buccaneer S.Mk 1 showed itself to be a sprightly aerobatic mount, provided energy was watched closely.

– was ARNA (A Royal Navy Aircraft) which, when appended to the manufacturer's name, became the Blackburn ARNA. The derivation 'nana' stayed with the aircraft. White anti-flash Buccaneers became 'peeled nanas' and, in their later years, the S.Mk 2s were referred to by the more dignified 'banana jet'. Other (more far-fetched) reasons advanced for the name include the fact that the Buccaneer was vaguely banana-shaped.

In recent years, the popular aviation press has started to refer to the aircraft as 'the brick'. This name has never had any currency within the ranks of those who flew or serviced the Buccaneer, and is a continuing source of some irritation to them.

No. 801 Squadron had the honour of becoming the first front-line Buccaneer unit, recommissioning on 17 July 1962 under Lieutenant Commander E. R. 'Ted' Anson (previously senior pilot on 700Z and later, in 1976, captain of HMS *Ark Royal*). This squadron had relinquished its Sea

XK534 introduced the all-over anti-nuclear flash white scheme, and was the fourth aircraft delivered to 700Z Flight. Only a few front-line aircraft wore this scheme, and all within No. 801 Squadron.

XK531 of the S.Mk 1 IFTU begins its take-off run from a rain-soaked Lossiemouth runway. The modest take-off performance, even on land, was the S.Mk 1's Achilles heel, and led to the urgent search for more powerful engines with which to power the S.Mk 2.

Above: Seen high over southern England at the time of the Farnborough display in 1962, this No. 801 Squadron S.Mk 1 displays the anti-flash scheme with toned-down markings. The dielectric radome of the Blue Parrot radar was initially left unpainted. During this early period, the Ark Royal *deck letter (R) was presented in small form, but by the time the squadron went to sea in February 1963 it had been increased considerably in size.*

Far right: One of 801's Buccaneers is seen on the deck of Ark Royal *during the type's first carrier cruise. This was a work-up prior to the squadron embarking in* Victorious.

Hawk FGA.Mk 6s some two years earlier, on its return to the UK. Like No. 700Z, around a nucleus of whose personnel it formed, No. 801 was based at RNAS Lossiemouth, thus starting a connection between the Buccaneer and this Scottish airfield which was to last – albeit with a break – for something over 30 years.

At the time of its reforming, No. 801 Squadron had no aircraft, but soon built up to a strength of five, commencing with XN925, and to a total of eight by year's end. Five S.Mk 1s were loaned to No. 700Z Flight in August and September 1962, for use at the Farnborough air show. The first carrier deployment was in HMS *Ark Royal*, in which the squadron embarked on 19 February 1963 for a four-week cruise. Contemporary reports differ as to whether these aircraft carried the earlier grey/white colour scheme or were anti-flash white overall. Photographic evidence suggests that at least some were white; what is certain is that they carried codes starting 111 (e.g., XN932 R/115, XN928 R/119). This period at sea, which lasted for one month, represented part of a work-up and was a prelude to a major cruise aboard the newly-refitted HMS *Victorious* to the Far East. During this cruise the squadron disembarked for a two-week period in February 1964 to Embakasi, Nairobi as a show of force during a period of local disturbances in neighbouring Tanganyika. When the situation calmed to the extent that the Buccaneers' presence was no longer required, they returned to the ship on 22 February, and the cruise continued. *Victorious* finally returned to Portsmouth in July 1965, at the completion of its cruise and the end of its commission.

Right: Blackburn saw the West German navy as one of its most likely customers for the Buccaneer, and a series of demonstration flights was arranged, using XN924, among other aircraft. In the event, the Bundesmarine opted for the F-104G to replace its Sea Hawks in the maritime attack role.

Above: Soon after formation, No. 801 Squadron aircraft were involved in the 1962 Farnborough air show, loaned to 700Z Flight.

Right: During the Farnborough show the novel bomb bay arrangement was demonstrated. Door rotation was accomplished swiftly to reduce any aerodynamic problems.

Into service

No. 801 Squadron formally commissioned on the Buccaneer S.Mk 1 in July 1962, formed from a nucleus of crews from 700Z Flight, and led by that unit's Senior Pilot, 'Ted' Anson. However, the Buccaneer was far from a matured system at the time, and it was not until February 1963 that the squadron went to sea for a work-up cruise. The first major cruise, to the Far East, began in August 1963, marking the full entry into front-line service of the type.

Strike Headquarters Squadron

Reformed at RNAS Lossiemouth on 15 January 1963 from the remains of No. 700Z Flight, No. 809 Squadron was commissioned as the Strike Headquarters Squadron – effectively the shore-based operational flying training unit with five Buccaneer S.Mk 1s (FAA records show XK531, XK532, XK533, XK534 and XK535, although the latter is recorded as having been written off the previous year in 700Z service) and a Hunter T.Mk 8 for pilot training and dual checks. Aircraft strength eventually reached 14, which was higher than that of the embarked squadrons. As well as carrying out continuing trials work, No. 809 Squadron did occasionally embark aircraft aboard RN carriers, and also took part in exercises. However, No. 809's principal task was to train pilots and observers for the front-line Buccaneer squadrons, an activity which continued until 26 March 1965, when it lost its identity and was renumbered as No. 736 Squadron in recognition of its second-line status. No changes in crews or aircraft were involved in the change, which took place, almost without comment, over Easter block leave.

The second – and final – front-line Buccaneer S.Mk 1 unit to form was No. 800 Squadron, which was recommissioned on 18 March 1964. Like the other FAA Buccaneer squadrons which preceded it, No. 800 had Lossiemouth as its shore base, and received an initial complement of six Buccaneer S.Mk 1s and a Hunter T.Mk 8. The commissioning warrant was presented to the OC, Lieutenant Commander J. C. Mather, by the Flag Officer, Naval Air

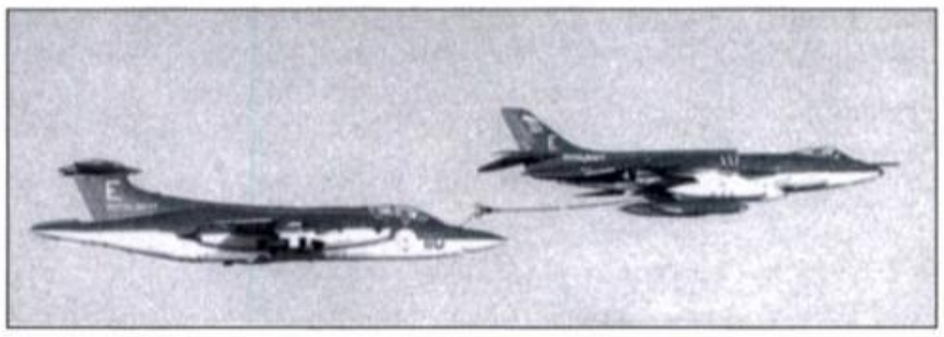
Left: As befitted an aircraft whose main task was tactical nuclear strike, Buccaneer S.Mk 1s adopted an all-over anti-nuclear flash white scheme, with pale blue/pink roundels. This aircraft, seen during a low-level overland training mission, wears the phoenix badge of No. 809 Squadron on its intake.

Below: While a plane-guard Whirlwind hovers off the carrier's port beam, an S.Mk 1 of No. 801 Squadron 'hooks on' aboard Ark Royal *in February 1963. The squadron moved to* Victorious *that year.*

Command, Vice-Admiral Sir Richard Smeeton, at a ceremony at Lossiemouth. A photo from the occasion depicts two Buccaneer S.Mk 1s on the flight line, coded 106 and 107, both carrying HMS *Eagle*'s 'E' tailcode and both finished in the grey/white paint scheme.

Beira Patrol

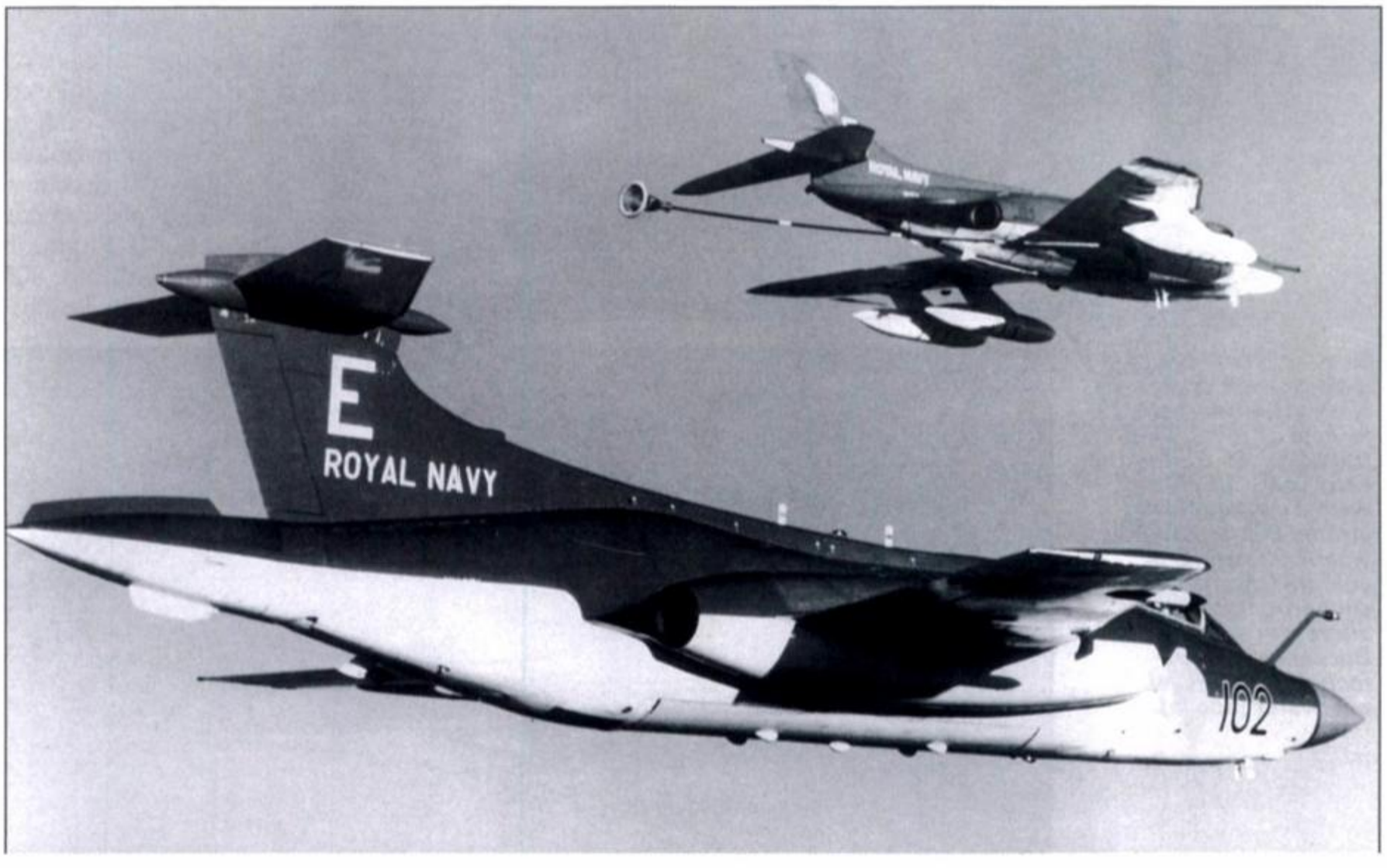
Following a period of work-up and an appearance at the Fleet Air Arm Jubilee Review at RNAS Yeovilton on 28 May, the squadron embarked in HMS *Eagle* on 1 December 1964 on its first cruise. The following summer, an extended cruise took the squadron East of Suez, where several periods were spent ashore, its aircraft detached to Changi on four shore calls. The carrier was rushed to Aden in October 1965 when the situation there worsened, and No. 800 was heavily involved in overflights and reconnaissance sorties over the Protectorate. It was subsequently ordered to sail from Singapore on 20 November 1965, to take up station off the coast of Rhodesia following that country's unilateral declaration of independence. This latter deployment again illustrated the inherent flexibility of the carrier to deploy air power 'wherever and whenever required'. *Eagle* and its air group had arrived, unannounced, off the coast of Tanzania four days before the much-heralded RAF deployment of Javelins to Zambia. There followed a period of intense activity, with *Eagle*'s air group being used to enforce the international blockade against Rhodesia. This involved keeping a very close eye on shipping in the vicinity of the port of Beira, which was the coastal terminal of the oil pipeline to Rhodesia, and the deployment became known as the Beira Patrol. No. 800 Squadron flew its Buccaneers on patrols from dawn to dusk, tasked with ship plots and tanker reconnaissance, with the occasional launch of a single aircraft going high-level out to 500 miles (805 km). There were no diversion airfields, and



The Scimitar F.Mk 1 was the Buccaneer's predecessor in the Navy's attack squadrons, and did not leave front-line fleet service until 803 Squadron returned from Ark Royal *in October 1966. Four of the aircraft were operated as tankers for the Buccaneer force by 800B Flight, adorned with a foaming beer tankard on the fin.*

800B Flight

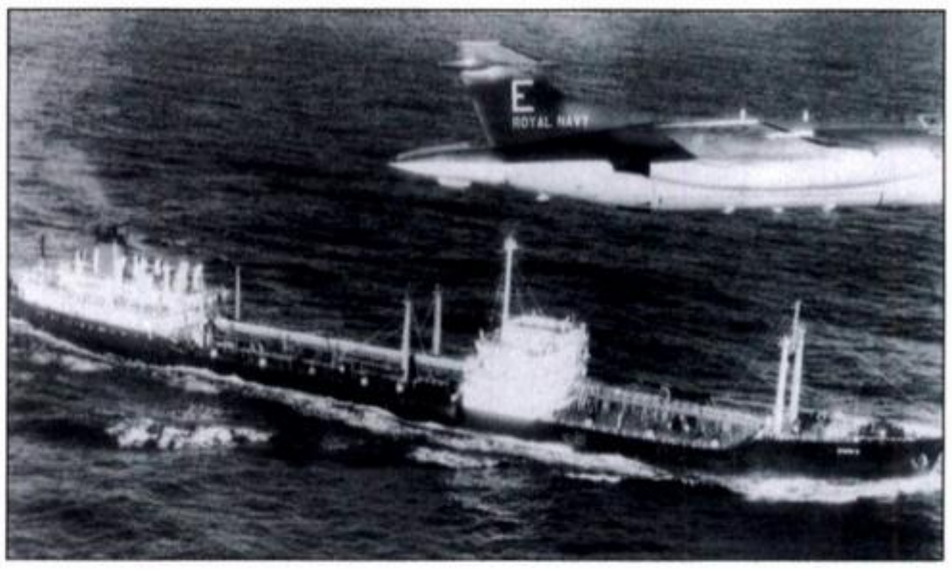
An important element in the early days of Navy Buccaneer operations was the provision of inflight refuelling by 800B Flight. Owing to the low thrust of the Gyron Junior engines, the S.Mk 1 struggled to get airborne from a carrier deck with a full fuel and weapon load. Rather than download the latter, or re-role Buccaneers themselves as tankers, aircraft were launched with reduced fuel and then topped up by a Scimitar F.Mk 1 tanker. Four of the latter were operated by 800B Flight, dedicated to the Buccaneer refuelling mission and deployed alongside the Buccaneers of No. 800 Squadron aboard HMS *Eagle*. They performed sterling service in support of the Buccaneers during the 1965/66 Beira patrol.



Above: Toss bombing was a regular means of delivering free-fall weapons, as demonstrated here by an S.Mk 1 of No. 809 Squadron. Dive attacks were also frequently employed.

Beira Patrol

When Rhodesian Prime Minister Ian Smith declared unilateral independence on 11 November 1965, Britain imposed a trade embargo, with UN backing. HMS *Eagle*, with No. 800 Squadron embarked, took over from HMS *Ark Royal*. Buccaneers were used in monitoring ship movements around the Mozambique port of Beira, the principal location for the import of oil into Rhodesia.



A Buccaneer from No. 800 Squadron checks on the movements of SS Joanna V during the Beira blockade. 800 Sqn and its 'mother' (Eagle) were on station until relieved by Ark Royal (and 803 Sqn's Scimitars) in May 1966. The photograph was taken by the F95 camera of another Buccaneer.

air-to-air refuelling was extensively used, Buccaneers refuelling routinely from Scimitars or Sea Vixens.

No. 800 was to remain with HMS *Eagle* throughout its life with the Buccaneer, although the S.Mk 1 era came to an end on 14 August 1966, when the squadron disembarked to Yeovilton and then Lossiemouth, prior to receiving the S.Mk 2.

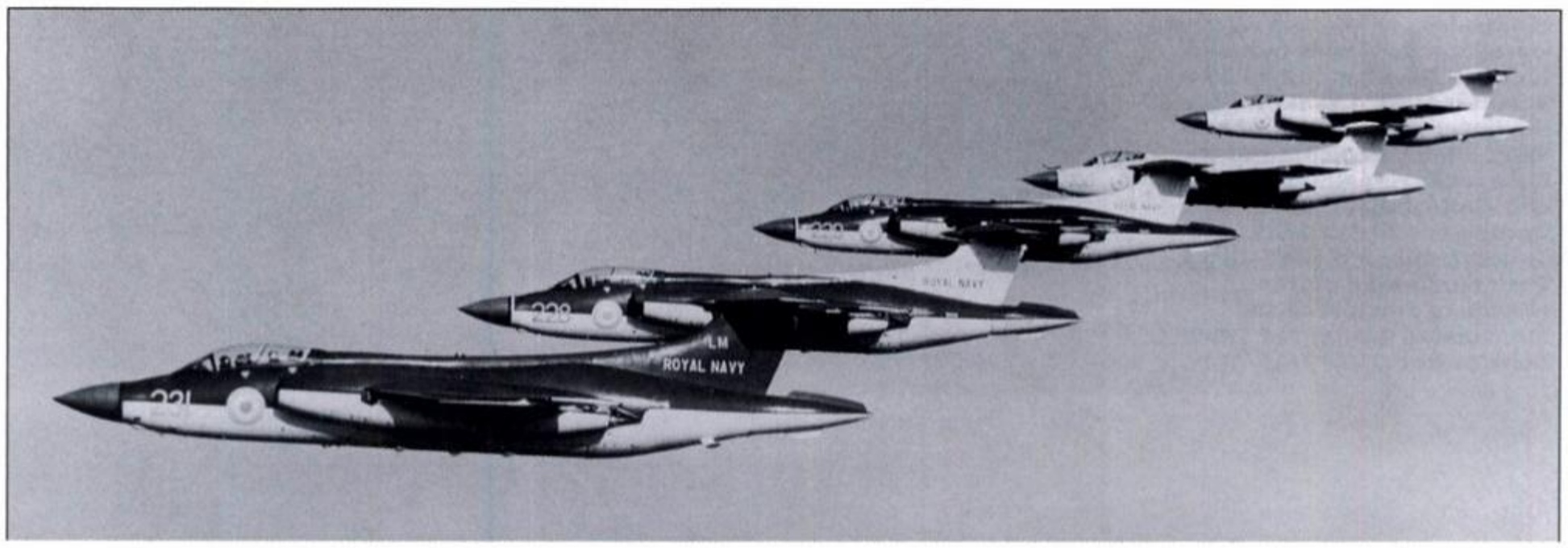
Provision for inflight refuelling had been built into the NA.39/Buccaneer design from the start, and XK491 had been allocated to refuelling trials. The initial provision, though, was for a fully retractable probe, fitted ahead of and to starboard of the cockpit windscreen. In tests, this was found to cause aerodynamic problems, and the eventual solution adopted was to fit a fixed probe, still offset to starboard, with a higher position for the nozzle to minimise the airflow disruption to the starboard engine. The change to a fixed (but removable) probe was made early in the first production batch, and all S.Mk 1s were subsequently given this provision.

Buddy tanker

As a tanker, the Buccaneer S.Mk 1 could mount an underwing Flight Refuelling Mk 20 pod containing a hose-and-drum unit. Earlier plans for a more complete buddy tanker fit for the Buccaneer S.Mk 1, involving removing the bomb bay door and fitting a centre-line pack containing hose-and-drum unit plus additional fuel tanks, were later abandoned.

Throughout its service life, the Buccaneer had a secondary role as a buddy tanker, with a FR Mk 20 pod mounted under the starboard wing on station 2. This had the advantage that a strike/attack aircraft could be reroled relatively quickly. The Royal Navy made use of this capability on both S.Mk 1 and S.Mk 2, to 'top up' departing aircraft after take-off and to extend sortie duration and range. In later years, the RAF made similar use of Buccaneer S.Mk 2s as tankers, although RAF Germany's Buccaneer S.Mk 2B aircraft were rarely – if ever – equipped with refuelling probes, so could not act as receivers.

No. 800B Flight, based at RNAS Lossiemouth and associated with No. 800 Squadron, formed on 9 September 1964 with four buddy tanker-equipped Scimitar F.Mk 1s.



Destined to be the longest-lived of the Navy squadrons, No. 809 formed as the S.Mk 1 training unit. During the early years, its aircraft were a common sight around Lossiemouth, wearing a variety of colours (right). The squadron trained aircrew in all facets of Buccaneer flying, including low-level overwater (above).

Buccaneer S.Mk 1
No. 800 Squadron
HMS *Eagle*

No. 800 Squadron was the second front-line unit to form with the Buccaneer. After a short work-up cruise, the squadron embarked in *Eagle* in August 1965 for a major cruise which lasted for nine days short of a year. During this cruise the ship was on station during the Indonesian conflict, subsequently conducting operations off Aden during a period of insurrection, and finally manning the Beira Patrol. This aircraft is depicted with its bomb bay rotated to reveal the Red Beard nuclear weapon. This weapon was mainly carried by No. 801 Squadron in the early days although No. 800 was cleared to carry it.

Weapon system
Although primitive by today's standards, the Buccaneer was equipped with a state-of-the-art weapon system based around the Ferranti Blue Parrot (AIRPASS III) radar, analog and early digital computers, master reference gyro, radio altimeter and an Elliott autopilot. Continual updating increased the capabilities of the system. The radar provided search and mapping functions, and also gave range data for semi-automatic bombing. Once a target was designated, the system generated a steering signal for the pilot. This commanded a pull-up for toss bombing, while a timer released the bomb automatically at the computed point. An audio tone ended when the bomb was released, giving the pilot his cue to initiate evasive action.

Undercarriage
Built to be immensely strong to absorb high sink rate carrier landings, the undercarriage employed a Dowty levered suspension design with oleo shock absorbers. Goodyear made the wheels and tubeless tyres, and also the anti-skid braking system. Nosewheel steering was available up to 50° either side of the centreline. In later Navy aircraft a pre-armed automatic retraction feature was incorporated for deck launches. A small bumper wheel was fitted under the rear fuselage

Cockpit arrangement
To improve forward visibility for the observer in the rear seat, the two seats were each offset from the centreline by 2 in (5 cm). The pilot's seat was offset to port, with the observer's offset to starboard and slightly higher.

Nocturnal attacks
For attacks at night Buccaneers initially used the Gloworm flare rocket (based on a 3-in RP). Eight were carried and fired in a banking turn so that they fanned across the target. Later, the Lepus flare was used for illumination, tossed above the target. Both systems employed flares which descended by parachute.

Red Beard delivery
Red Beard required a long flight time to arm the system, and to allow the Buccaneer sufficient time to escape the blast. Level drops had to be undertaken from at least 12,000 ft (3658 m), but the usual methods were the 'long toss', which involved a 30° loft, 'varitoss' (60° loft) or the over-the-shoulder manoeuvre, usually flown at high speed (typically 540 kt). The latter required the Buccaneer to overfly the target before pulling up into a loop. The bomb was released at 105°, with the aircraft pulling through the loop and diving back to low level on a reciprocal heading.

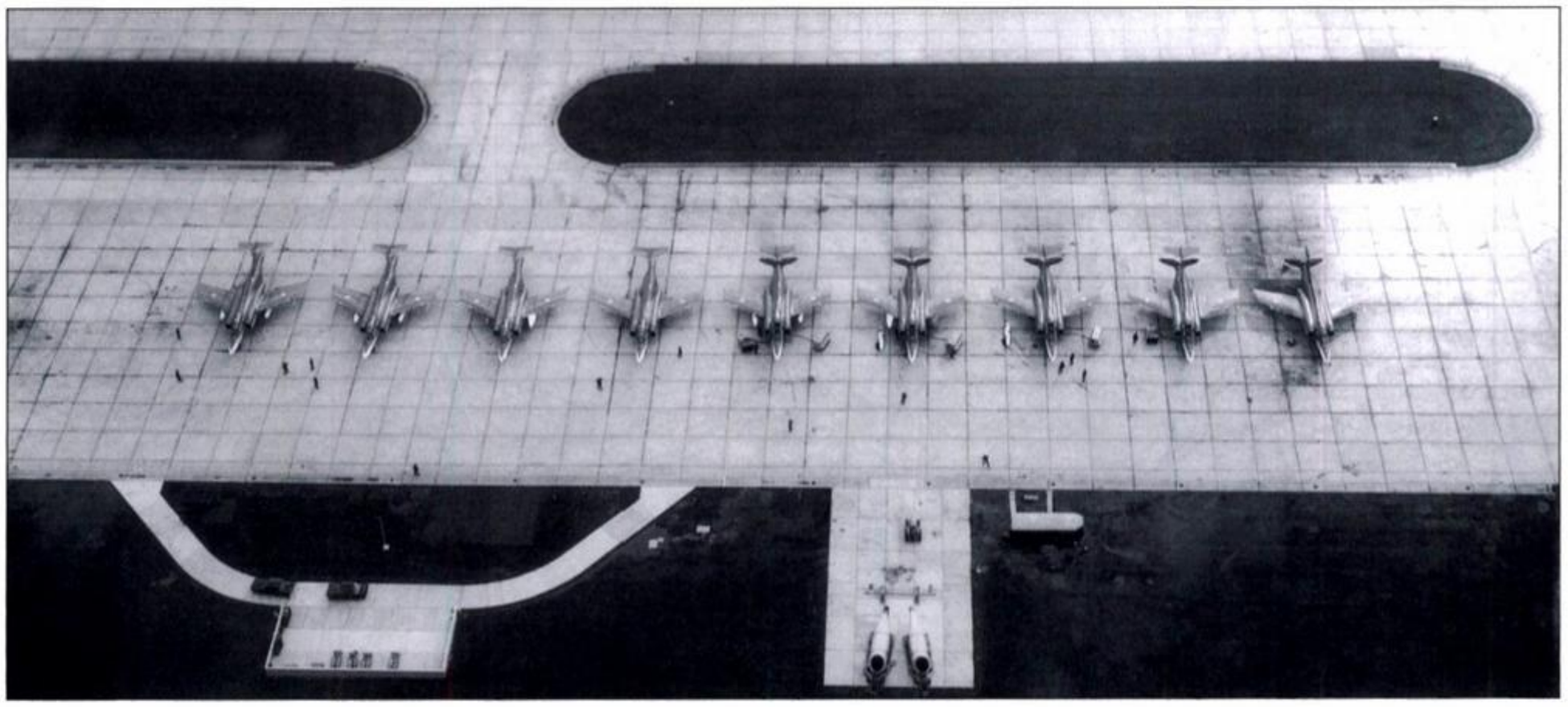
Refuelling probe
After abortive trials with a retractable unit, the Buccaneer was fitted with an optional bolt-on probe, offset to starboard to avoid impairing the pilot's direct forward vision.

Bomb door
A key feature of the Buccaneer was its rotating bomb door assembly, which had the armament carried on the inner side. Standard hinged doors could not be used at the high speeds attained by the Buccaneer. The original concept called for the bomb door not only to rotate, but also to drop down. This was required by the Green Cheese guided weapon for its seeker head to acquire the target prior to release. When Green Cheese was cancelled, Blackburn reverted to a rotating bay.

Gyron Junior
Originally developed by the de Havilland Engine Company, the Gyron Junior became a Bristol Siddeley product on 1 August 1962 when the latter took over the assets of the former. In DGJ.1 form it first ran in August 1955, the version for the Buccaneer being designated DGJ.2 or Mk 101. The main difference was the addition of an air bleed manifold around the combustion chamber to provide air for the BLC system. The DGJ.2 also featured variable-incidence first-row stator vanes and inlet vanes. The engine was nominally rated at 8,000 lb (35.6 kN) thrust, but was derated in the Buccaneer to 7,100 lb (31.59 kN) at sea level. This gave a low specific fuel consumption and, by the temporary use of higher jetpipe temperature, allowed the full recovery of thrust with the BLC system working.

Reconnaissance

To perform the reconnaissance mission the Buccaneer could carry a camera pack in the forward part of the bomb bay. A variety of camera configurations was possible, mostly based on the F95 camera with 4-in (10-cm) or 12-in (30.5-cm) lenses. Up to six cameras could be carried. Vertical sensors were housed in the forward part of the crate, with F95s mounted in the two forward positions. The aft vertical position could alternatively accommodate two night F97 cameras. A prominent blister fairing housed a forward-facing F95 while side-looking oblique cameras were carried in the flat sides of the crate. In the rear part of the weapons bay was a crate for photo-flash bombs for night photography. Although regularly fitted, the flash crate was not used. The Navy made extensive use of the reconnaissance pack, while the RAF, although it took over the equipment, rarely employed it.



Above: An S.Mk 2 from No. 700B Flight pulls g over the Morayshire coast. The camera pack allowed the Buccaneer to become an effective reconnaissance platform, principally used for maritime operations. This use continued with the RAF, but was largely stopped when crews were given hand-held cameras with which to photograph Warsaw Pact ships.

Right: A photograph from a side-facing camera captures the Buccaneer S.Mk 2s of No. 801 Squadron on the ground at Lossiemouth.

Top right: This underview shows the recce pack to good effect. The three windows to the front were for various vertical installations while the blister housed a forward-facing camera. Note the small windows for the side-facing F95s. The flare pack had 33 doors for 198 individual photoflash bombs.

Above right: The camera/flare crates could be carried by both S.Mk 1s and S.Mk 2s – here it is seen in the first variant. The crates rotated to allow ground access to the film magazines and for reconfiguring the camera suite.

Their operational role was to increase the range of carrier-borne Buccaneer S.Mk 1s which, because of the relatively low installed power of their Gyron Junior powerplants and available carrier catapult power, could not always be launched at their maximum all-up weight. The solution was to launch a tanker-configured Scimitar F.Mk 1 of No. 800B Flight ahead of the Buccaneers – which were launched with maximum weapon load but reduced fuel – to top them up after take-off. No. 800B embarked in *Eagle* between 1964 and 1966, its primary 'customers' being the Buccaneer S.Mk 1s of No. 800 Squadron.

The unofficial emblem on the fin of the Scimitars was a foaming tankard, which followed from the squadron's adoption by Whitbread Breweries. The use of these Scimitars aboard HMS *Eagle* was a good solution to the problems of the Buccaneer S.Mk 1, and allowed the use of the Buccaneers in their primary strike/attack role, rather than having to configure Buccaneers themselves as tankers. No. 800B disbanded on 14 August 1966, the same date on which No. 800 Squadron ended operations with the Buccaneer S.Mk 1.

S.Mk 1 in retrospect

The S.Mk 1 was undoubtedly successful in its role, but was generally agreed to be underpowered, especially given the requirements of the boundary layer control system (which bled air from the compressor) in the catapult take-off and carrier landing cases.

The S.Mk 1 had given the Fleet Air Arm a potent low-level attack aircraft, which had quickly supplanted the Scimitar F.Mk 1 in the strike (i.e., nuclear) and attack (conventional) roles, and had provided a ride at low level which surpassed that of any of its contemporaries. Commander Leahy is reported in 1962 as likening the difference to "driving down a cobbled street in a Citroen ID with its independent suspension and driving down the same street in a Model T Ford." The resultant comfort factor enabled S.Mk 1 crews to make longer low-level target approaches with less fatigue, which inevitably resulted in more effective (accurate, survivable) attacks.

The S.Mk 1 was capable of carrying a variety of offensive weapons in its rotating bomb bay and on the four underwing stations. Little can be said of the nuclear stores carried,

Blackburn Buccaneer

Two photographs show an 800 Squadron aircraft during trials aboard HMS Eagle in 1964, prior to the unit's work-up cruise on the carrier which began in December. At left, deck crew bustle around an aircraft to prepare it for launch, while below, an aircraft undertakes DLP (deck landing practice). The boundary layer control 'blowing' system was used during both take-off and the approach, reducing approach speed by about 15 knots compared to the unblown configuration. The S.Mk 1 only undertook two major Navy cruises, one with 800 and one with 801. Both voyages were conducted 'east of Suez'.

although photos have been seen of an S.Mk 2 with a single, large nuclear device, apparently carried on a central station inside the bomb bay door, surrounded to half its depth by an aerodynamic fairing. This weapon was Red Beard, also known as the Target Marker Bomb (TMB) or the '2,000-lb special weapon'. Replacement of this earlier nuclear weapon on the Buccaneer squadrons by the WE177 did not occur until 1969, which was some time after the S.Mk 1 was retired from front-line service. Free-fall (rather than retarded) 1,000-lb bombs with various fuses were the primary attack weapon, the S.Mk 1 being capable of carrying eight (four in the bomb bay, plus one on each underwing pylon), although six was a more usual fit. Underwing pods of 2-in RPs (rocket projectiles) were a frequently seen fit, each pod carrying 36 rockets. They were later replaced by the MATRA SNEB, having 18 68-mm projectiles to a pod ('SNEB can'), offering a heavier warhead. SNEBs were used by Navy squadrons until the end of Buccaneer operation in 1978, and were also carried by RAF S.Mk 2s in their early years of service.

A reconnaissance fit was available on the S.Mk 1, consisting of a crate fitting into the bomb bay and mounting six F95 cameras. Fitted behind the cameras was a flash crate, although it appears that this night capability was not used by the Navy. Gloworm rockets, though, could be carried on an underwing pylon, and were used by Royal Navy squadrons to provide illumination for night attacks. It is not strictly true to say that the S.Mk 1 did not carry any guided weapons; Bullpup was held in the Navy inventory, and was carried both by Buccaneer S.Mk 1 (after compatibility Mod 5031) and (more usually) by Scimitar F.Mk 1 from 1964. The first live firing is believed to have been demonstrated from a Buccaneer in spring 1965.

The Ferranti Blue Parrot radar – which equipped all marks of Buccaneer – did not give the aircraft any terrain-following capability. The Buccaneer could not be classed as truly all-weather capable, at least in the overland role, but was nevertheless very much ahead of its time. Blue Parrot was designed for the pure anti-shipping role, but was used to good effect by Nos 15, 16 and 208 Squadrons as an overland mapping radar, although relying heavily on 'radar prediction' prior to take-off.

The Buccaneer S.Mk 1 gave the Navy an aircraft which went a long way, low down and fast, with a radar which provided weapon delivery and navigational modes. In short, the S.Mk 1 was good. With re-engining, it would be better. Perhaps most importantly, the S.Mk 1 paved the way for the much more effective S.Mk 2, which thus had a smoother entry into operational service.

S.Mk 2 is born

As early as 1959, Blackburn had been examining alternative engines to the Gyron Junior, be they actual or projected. They included developments of the Gyron Junior offering substantially increased thrust. Most promising was the Rolls-Royce RB.163 Spey turbofan, which was committed to production in its civil form for the de Havilland Trident airliner. It was offered in a military version, giving 11,380 lb (50.61 kN) of thrust and an improved specific fuel consumption (sfc) for a modest increase in installed weight and an increase in mass flow which would require changes to both intake and jetpipe. These design changes were refined during 1960, by which stage the Spey Mk 101 had been effectively selected for the Mk 2 Buccaneer.

The thrust of the non-afterburning – or unreheated, in the vernacular of the time – Spey was so much higher than that of the Gyron Junior that the extra loss of engine thrust when flap blow was selected was no longer of any great significance. The S.Mk 1's shortfall in carrier take-off performance at high weights was cured at a stroke, while the new variant also had a respectable land-based take-off capability. The boundary layer control system was redesigned on the S.Mk 2 to take advantage of the engine's higher mass flow, and the result was a reduction of 8 kt (9.2 mph; 14.8 km/h) on launch and 2 kt (2.3 mph; 3.7 km/h) on landing, compared with the S.Mk 1. In short, the Spey was an excellent match for the basic Buccaneer airframe and allowed Hawker Siddeley (into which Blackburn Aircraft Ltd had merged, to become the Hawker Blackburn Division in May 1963) finally to exploit the aircraft's full potential. The S.Mk 2 also proved a more reliable and maintainable aircraft in service – a feature much appreciated by the RAF, which was to operate the type for over 20 years.

Viewed externally, the Spey installation necessitated enlarged, elliptical (rather than the S.Mk 1's round) intakes,

After a brief work-up on Ark Royal, No. 801 Squadron moved to Victorious for its one major cruise with the S.Mk 1. In February 1964 the squadron and carrier temporarily left the Far East to deploy Buccaneers ashore to Embakasi in Kenya. They provided cover for the police action in Tanganyika, but were not used. This aircraft is seen on a DLP from the deck of 'Vic', the airbake just beginning to close. The standard approach procedure called for the aircraft to land with the airbrake fully open. This allowed the throttles to be run at high power to provide sufficient bleed air for the BLC system. Also, shutting the brake provided, in effect, rapid extra thrust in the case of a missed wire or emergency.

S.Mk 2 prototypes

From an early stage in Buccaneer development it was obvious that more power was needed. The search for an uprated engine led to the adoption of the Spey turbofan, requiring only a redesign of the engine bay. Two development batch aircraft, XK526 and XK527, were taken from the HoSM trials fleet for conversion to the new variant, the first flying from HoSM on 17 May 1963. This aircraft now resides on the gate at RAF Honington.

Right: This view of S.Mk 1 XN953 and S.Mk 2 prototype XK526 serves to illustrate the major external difference between the two variants: the much larger oval intakes of the Spey-engined aircraft. The Mk 2 also introduced more pointed wingtips.

Above and above right: The dummy deck and catapult at RAE Bedford played a significant part in the Buccaneer's development. Here the first S.Mk 2 conversion is seen undertaking trials, armed with 24-round rocket pods (not adopted for service use). Note the photo-calibration marks.

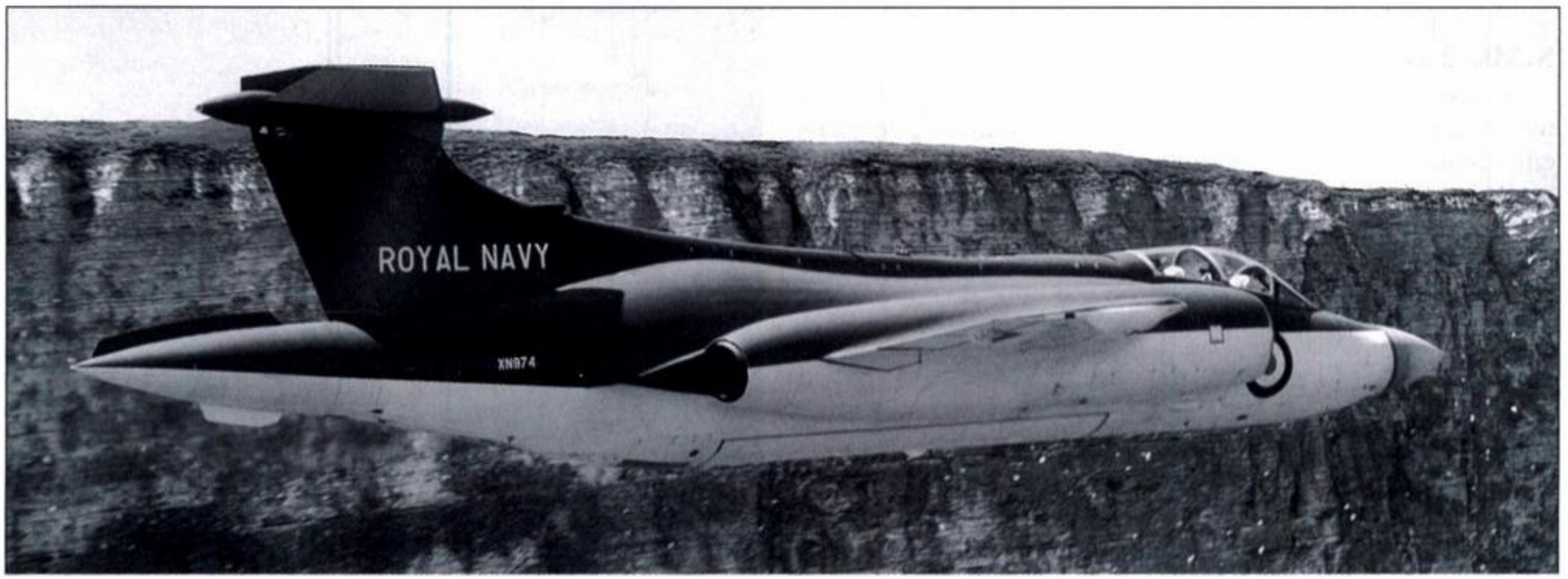
with the new jetpipes canted downwards and outwards. Internally, changes were to be more extensive, especially as regards mounting the new engines, while it was decided at this stage to introduce a new AC electrical system. A detail change involved the fitting of different, more pointed wingtips, which offered improved range in the cruise.

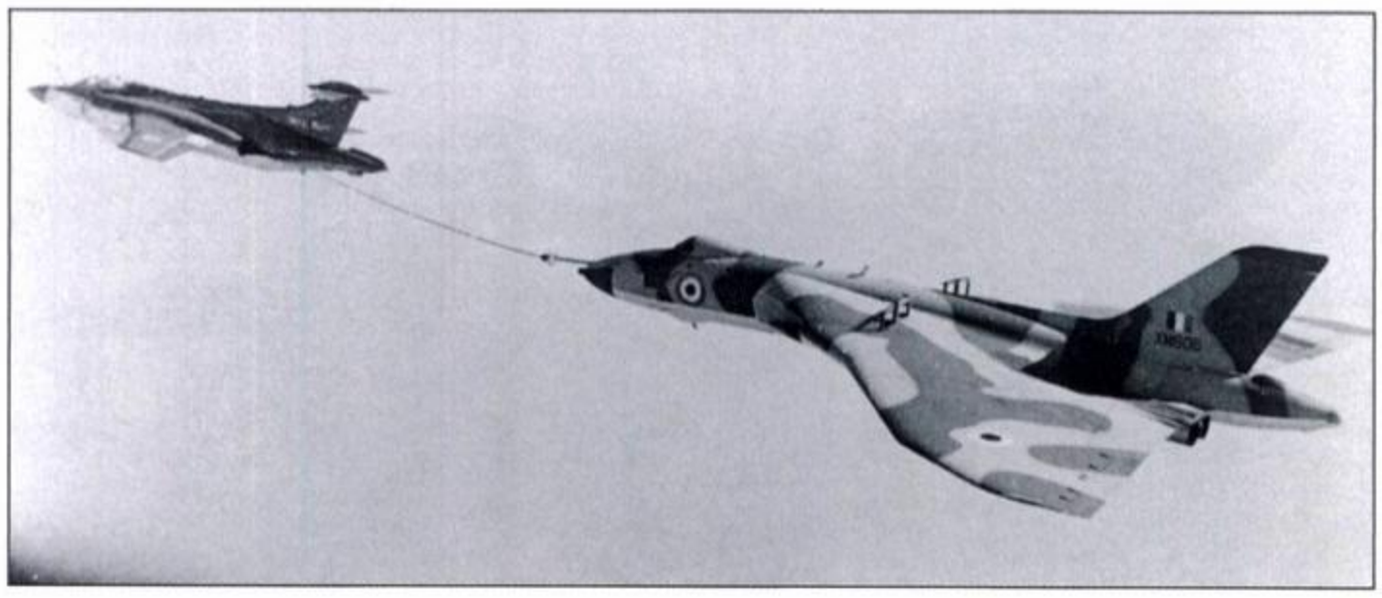
The Mark 2 programme became public during 1961, before even the S.Mk 1 had reached squadron service, and Hawker Siddeley announced on 8 January 1962 that the Spey-engined S.Mk 2 had received a production order for the Royal Navy. Such was the pace, in 1961, of the S.Mk 1 development programme that no S.Mk 1 airframes could be made available for prototype S.Mk 2 conversion that year, although XK526 and XK527 were earmarked for the future programme.

XK526 was the first conversion to S.Mk 2, and its first flight was made from HoSM on 17 May 1963, piloted by Derek Whitehead, to be followed by XK527 on 19 August 1963. Despite its complexity, the test programme progressed without major hindrance, and production S.Mk 2s started to roll off the Brough line from early summer 1964. They were in a production batch starting XN974, with XN974 itself making a first flight from HoSM on 5 June 1964. On 7 April 1965, the production tempo allowed the S.Mk 2 IFTU to form, with No. 700B Flight commissioning at Lossiemouth on 9 April 1965 with four early-production S.Mk 2s and the inevitable Hunter T.Mk 8. The intensive flying trials for the S.Mk 2 – as a new variant of the Buccaneer, rather than an all-new type – lasted only a few months. This was aided by the availability to No. 700B of no fewer than eight S.Mk 2 aircraft. Weapon drops were carried out primarily on Lossiemouth's 'own' range at nearby Tain. Another major area investigated was that of flight refuelling, both as a tanker (with an underwing-mounted FR Mk 20 pod) and as a receiver. Carrier trials were carried out aboard HMS *Ark Royal* by XN975 of the A&AEE's Naval Test Squadron; No. 700B made its own first deck landing in the S.Mk 2, on HMS *Centaur*, on 29 July 1963. Other Boscombe Down S.Mk 2s detached to the United States in July/August 1965, operating from NAS Pensacola, Florida and from USS *Lexington* for hot weather and carrier-compatibility trials. One of the three aircraft (XN974 – the others were XN975 and XN976) caused something of a stir on its return to the UK by flying non-stop and unrefuelled from Goose Bay to Lossiemouth, a distance of 1,950 miles (3138 km).

Its work completed, No. 700B Flight disbanded on 30 September 1965, ready for the commissioning of the first

Above and right: XN974 was the first production S.Mk 2, flying for the first time on 5 June 1964. It is seen here fitted with wingtip camera pods. It was retained by the manufacturers as a trials aircraft, surviving long enough to be operated for many years by British Aerospace. This historic machine now resides at Elvington with the Yorkshire Aircraft Museum.





front-line S.Mk 2 squadron. Just as No. 801 Squadron had been the first front-line Buccaneer S.Mk 1 unit, it was similarly selected to be the first operational unit to receive the S.Mk 2. After less than three months of disbandment following the end of its S.Mk 1 flying, No. 801 was recommissioned at Lossiemouth (where else?) on 14 October 1965. The aviation press of the day made much of the fact that the Spey-engined S.Mk 2 had gone into front-line service in less than 30 months from first flight of the prototype. This was, indeed, quite an achievement. The normally staid *Flight International* went even further, noting that the S.Mk 2 "may be considered by the US Navy as an A-6 replacement at some future date."

Battle of Trafalgar remembered

The S.Mk 2's introduction into service was underlined by the flypast over Trafalgar Square in central London made on 18 October – just four days later – by S.Mk 2 XN980 of No. 801 Squadron. Piloted by 801's boss, Lieutenant Commander John de Winton, the Buccaneer made two passes across the city, to mark the 160th anniversary of the Battle of Trafalgar. Contemporary photos show the aircraft in grey upper surfaces with white undersides – the era of anti-flash white had already passed – and a fixed refuelling probe.

The general perception of the Buccaneer at this time was of a specialist low-level strike/attack type for the Royal Navy. This belief was current in public circles as well as in the defence establishment. While it would be over-simplistic to dismiss the Buccaneer as 'the aircraft the RAF did not want', there was more than a hint of truth in this statement. 1965 was the year of the cancellation of TSR.2, of the ordering of the F-111K to replace it, and of much agonising over the choice of J79 or Spey for the RN's and RAF's Phantom buys. For the Royal Navy, the future of the first of the new generation of aircraft-carriers, CVA-01, was very much under discussion. Its cancellation, confirmed in 1966, would mean that the Royal Navy would be left with a decreasing number of attack carriers, and would inevitably relinquish fixed-wing flying from carriers in the mid-1970s. From this point onwards, the requirement for FAA Buccaneer aircrew started to diminish.

It was against this uncertain defence situation that the Buccaneer S.Mk 2 entered front-line Royal Navy service. Whatever might take the place of TSR.2 in RAF service – F-111K, a nebulous Franco-British AFVG project or a Spey-engined Mirage IV – there was little consideration given to the possibility of an RAF Buccaneer in the corridors of the Ministry. Blackburn, realising that the Royal Air Force could do a lot worse than the Buccaneer as a Canberra replacement, came up with various projects based on the S.Mk 2, some beginning to approach the TSR.2 and F-111K in capability although lacking, of course, their Mach 2 dash performance. Among these was the P.145 project of October 1966, which would have become the Buccaneer S.Mk 3, had it been built. Based around the improvements made for the South African S.Mk 50 – rocket-assisted take-off to increase take-off thrust and performance, larger 430-Imp gal (1955-litre) underwing fuel tanks, a four-wheel bogie undercarriage design (to allow operation from less-prepared runways), the provision of stand-off weapons (including Martel) and a new nav/attack system and radar – the P.145 would have been a capable strike/attack type. The RAF still had its eyes on a purchase of F-111K, so entertained Hawker Siddeley's proposals with politeness, but little real interest. The P.145 thus joined a number of other Buccaneer-based projects on the 'not built' paper mountain.

South African interest

Despite the Buccaneer's undoubted qualities, the list of export successes must simply record 'South African Air Force – 16 Mk 50s'. Interest on behalf of the US Navy in the late 1950s failed to materialise, as did a more significant degree of West German interest in replacing the Bundesmarine's shore-based Sea Hawks with Buccaneers. The reasons for this lack of success were probably more associated with a lacklustre presentation of the aircraft by a company more used to selling to the UK government than to 'true' (non-captive, foreign) customers, and with government-imposed bans on selling a 'bomber' aircraft to certain nations which might otherwise have ordered it, than with any shortcomings of the aircraft itself.

In 1962 discussions with the South African government regarding a possible order for the South African Air Force (SAAF) became detailed. The subject of interest was the S.Mk 2, which had yet to fly, but incorporating significant changes to meet that country's requirements for land-based operation from 'hot-and-high' airfields. The contract was signed in January 1963 for 16 Buccaneer Mk 50s. This was in a period when the UK had normal relations with the

Above: A&AEE's 'C' Squadron extensively tested both versions of the Buccaneer. Here one of the S.Mk 2s (probably XN976) is seen refuelling a Vulcan B.Mk 2 from the Cottesmore Wing. The Buccaneer used the Flight Refuelling Ltd Mk 20C or Mk 20E buddy pod, usually counterbalanced by a slipper tank on the opposite wing.

Above left: XN976 was the first S.Mk 2 delivered for Royal Navy service, and it went immediately to the A&AEE's Royal Navy Test Squadron (as 'C' Squadron was alternatively known). Here it is seen during carrier trials aboard HMS Hermes in 1966.

S.Mk 2 IFTU

Following in the footsteps of 700Z Flight, which had performed the IFT work for the S.Mk 1, 700B Flight was in existence between April and September 1965. The brevity of the IFTU's career was largely due to the nature of the work, which was principally validating procedures and systems already cleared for the S.Mk 1. The work was carried out using eight aircraft.

No. 700B Flight was blessed with a large fleet of aircraft from the start, enabling it to stage this much-photographed five-ship to publicise the arrival in service of the S.Mk 2.

S.Mk 50 development

Essentially similar to the S.Mk 2, the S.Mk 50 introduced various features unique to this variant, most notably the auxiliary rockets and large tanks. These were developed between 11 October 1962, when South Africa placed its order, and the first flight on 9 January 1965. Aircraft 415 and 416 were the first to be delivered to Lossiemouth, where No. 24 Squadron, SAAF, had already activated for conversion, using borrowed Royal Navy S.Mk 1s.

The first S.Mk 50 is seen on a test flight from HoSM, complete with four Nord AS 30 missiles. The aircraft wore British 'B'-class registrations (G-2-1 to G-2-16) for flight testing. Note the additional strakes under the bomb bay.

The S.Mk 50's rocket-assisted take-off equipment was tested by the first aircraft at RAF Elvington. In spite of the enormous amount of design work which went in to the installation, and the substantial extra cost to South Africa, the equipment was never used operationally, its employment being restricted to a handful of air show displays. The system was originally specified so that the aircraft could deploy for operations from short, high airfields. This requirement failed to materialise.

country, and when the Simonstown Agreement – under which Britain offered South Africa maritime equipment and weapons to defend the important trade routes around the Cape of Good Hope – remained in force.

The S.Mk 50 was to be based on the S.Mk 2 with larger, 430-Imp gal (1955-litre) drop tanks and the addition of two Bristol Siddeley BS.605 rocket engines under the rear fuselage. These developed 4,000 lb (17.79 kN) of thrust each for 30 seconds, giving a total installed thrust of over 30,000 lb (133.42 kN) for a huge improvement in take-off performance, especially from 'hot-and-high' airfields. Manual wing-folding, achieved by removal of the latch pins and manhandling of the outer wing section, remained available. Initial misgivings about the use of high test hydrogen peroxide (HTP) in the rocket motors proved over-pessimistic, and the BS.605 installation was shown to work well. The first SAAF S.Mk 50, coded 411 but carrying B-class registration G-2-1, made its maiden flight from HoSM on 9 January 1965, painted with dark sea grey upper surfaces and blue undersides. Clearance of the BS.605 installation was rapidly achieved, together with that for the underwing carriage of four Nord AS30 ASMs.

Above: With a vast expanse of ocean to cover in the maritime role, it was natural that the SAAF should opt for the buddy tanker option.

Right: Initially intended for the maritime mission, the S.Mk 50 found its niche as an overland attacker. Its comfort and speed at low-level earned it the nickname 'Easy Rider' among SAAF crews.

At this point, politics intervened. International opinion had turned against South Africa and Harold Wilson's government announced that it would not entertain further South African orders beyond the initial batch of 16. It was at the time an open secret that South Africa had intended a follow-up batch of 14 S.Mk 50s; these were never ordered.

S.Mk 50 into service

No. 24 Squadron, SAAF reformed at Lossiemouth on 1 May 1965, initially using Buccaneer S.Mk 1s until new-build S.Mk 50s became available for their training and work-up. No. 24's first boss, Commandant Rogers, and three other aircrew had already trained on the Buccaneer, under conditions of some secrecy, with No. 809 Squadron from January 1965, and provided an experienced cadre. The work-up having proceeded satisfactorily, a date was set for delivery of the first eight aircraft to South Africa. Two formations, each of four aircraft, 412-419, started their long flight from Lossiemouth on 27 October 1965. Seven aircraft arrived, but 417 crashed into the sea south of the Canary Islands, on 31 October. Pointedly, the UK government reportedly refused even to allow a replacement aircraft to be built. As a result, the remaining eight aircraft were delivered by sea from Hull, in two batches – 421, 423, 424 and 426 on 5 August 1966 and 411, 420, 422 and 425 on 17 October 1966.

Home base for the squadron was to be Waterkloof, south of Pretoria. This airfield's elevation of nearly 5,000 ft (1524 m) above sea level was likely high in the list of justifications for the S.Mk 50's rocket installation. In practice, rocket-assisted take-offs were hardly ever used by the SAAF, save for the odd air show demonstration.

The SAAF used its Buccaneer S.Mk 50s long and hard through to their retirement in 1991. No. 24 Squadron remained the one and only operator, and its aircraft were rarely seen outside that country's borders. In their early years of service, SAAF Buccaneers operated alongside those from RN carriers in the annual UK/South African Capex exercises, held off the coast of South Africa. They continued until November 1973 under the terms of the Simonstown Agreement, but this was to be the last, as the Agreement was severed soon afterwards. S.Mk 50s were modified

Buccaneer S.Mk 50 No. 24 Squadron, SAAF Waterkloof

Despite the adoption of the Spey engine, the Buccaneer at full weight still used a large amount of runway to get airborne, largely due to the drop in thrust necessitated by the bleeding of air for the BLC system. Facing the further complication of 'hot-and-high' operations, the SAAF required extra take-off thrust. The adoption of auxiliary take-off rockets was the major difference between the S.Mk 50 (Blackburn B.136) and S.Mk 2, the South African machines retaining the arrester hook for use with runway gear, or even for goodwill visits to Royal Navy carriers (which, in the event, never materialised).

S.Mk 50 in action
Operations in Angola are believed to have begun on 4 May 1978 with two missions to the town of Cassinga, flown from Grootfontein. Later raids were also made into southern Zambia. Night attacks began in March 1979. Initially, attacks were restricted to 1,000-lb (454-kg) bomb and rocket attacks, but were later widened to encompass the use of Nord AS 30 guided missile.

South African differences
In addition to those mentioned, the S.Mk 50s also featured two small strakes on the rear of the bomb bay door and strengthened undercarriage. The S.Mk 50s were significantly updated during their career, acquiring threat warning receivers on the strike camera mounting, chaff/flare dispensers under the rear fuselage, an indigenously designed reconnaissance pack to replace the RN-style pack originally delivered, night attack flares and some different bomb armament.

Wing fold
The SAAF S.Mk 50s were completed without hydraulic wing-folding equipment, but the wing fold capability was retained, operated manually.

Slipper tanks
The main innovation introduced by the S.Mk 50 was the enlarged slipper tank, which could accommodate 430 Imp gal (1955 litres). These tanks were included in the S.Mk 3 proposal to the RAF as a TSR.2 competitor.

Nord AS 30
A key weapon of the S.Mk 50 was the Nord AS 30 missile. This was an enlarged version of the 290-lb (132-kg) AS 20 radio-guided missile (itself based on the Nord 5103 air-to-air missile), which was also supplied to South Africa although used only for training. The AS 30 weighed 1,146 lb (520 kg), of which 529 lb (240 kg) was the high-explosive warhead. The two-stage propulsion system consisted of a booster rocket and a sustainer. Pop-out fins deployed from the rear of the body for stabilisation. Range was approximately 7.5 miles (12 km) and speed at impact typically 1,640 ft (500 m) per second.

Wing planform
The compound sweep layout, and a decreasing thickness/chord ratio, was adopted following Blackburn's experience with the HP.88 Victor testbed. The inner wing stalled first, prolonging aileron effectiveness and avoiding pitch-up problems.

Nuclear S.Mk 50?
Various reports have surfaced alleging that one Buccaneer S.Mk 50 (422) was modified in 1987-89 to carry the South African nuclear weapon, of which six were built before the nuclear programme was terminated.

Rocket motors
To provide the extra take-off thrust required by the SAAF, Blackburn adopted two Bristol Siddeley BS 605 auxiliary rocket motors, housed in the rear fuselage with retractable thrusters. The BS 605 worked on a mixture of kerosene (drawn from the aircraft's standard fuel supply) and HTP (high-test peroxide), held in plastic tanks. The rockets provided an additional 8,000 lb (35.6 kN) of thrust for 30 seconds, for an installed weight penalty of 360 lb (163 kg) plus around 1,100 lb (500 kg) of HTP. The overall length of the rocket was 3 ft 6 in (1.07 m) and thruster diameter was 12 in (30.5 cm).

*The 68-mm **SNEB** rocket (right) was used by **Buccaneers** in the bush war, notably during the anxious defence and extraction of **South African** paratroops at **Cassinga**. **Buccaneers** expended many rockets against **SWAPO** vehicle columns during this action (**Operation Antler**) on 4 May 1978. In other raids the 'Buccs' dropped 1,000-lb bombs in low-level dive attacks or from medium level, often on command from a nav-lead **Canberra**. **Over 30 AS 30** precision missiles were also fired.*

in 1974 to fit a bomb bay fuel tank, and were capable of mounting an underwing FR Mk 20 refuelling pod, to function as buddy tankers to other Buccaneers or to SAAF Mirages.

Details of the aircraft's operational use are difficult to obtain, but reports have surfaced detailing a string of actions in Angola undertaken between 4 May 1978 and 6 February 1988. Buccaneer attacks often took place in concert with SAAF Canberras, which flew as nav lead on level bombing missions. Buccaneers also flew alongside Mirage F1AZs on bombing missions and undertook reconnaissance sorties using indigenously produced camera packs. In the later years of the war in Angola the Nord AS 30 missile was used successfully against radars and other targets which required precision attacks. At least 30 appear to have been fired.

Attack on the *Wafra*

One attack which certainly did take place was that against the crippled tanker *Wafra* off the South African coast in March 1971. With the vessel abandoned and drifting, the danger of a massive oil spill caused owners Getty Tankers and the South African government to agree to try to sink the vessel, to avoid a major pollution incident. Two Buccaneer S.Mk 50s were detailed to fly against the *Wafra*, and were detached to Langebaanweg, near Cape Town. The attack mounted by the two aircraft on 10 March involved launching four AS 30 ASMs; two hit the target, but the ship stayed afloat. The next day, a further AS 30 attack was made, but the *Wafra* stayed afloat until finally sunk by a depth charge attack by SAAF Shackleton MR.Mk 3s. This was one of the earliest live firings of an AS30 from a SAAF Buccaneer, and an expenditure of 12 missiles that failed to sink a static tanker – and all this in the glare of the world's press – must have been a salutary experience. More than anything, it probably focused the SAAF's attention on the fact that the AS30's capabilities were more limited than might have been hoped.

War in the bush

For nearly 10 years from 1978, SAAF Buccaneers were used in action against SWAPO (South West Africa People's Organisation) guerrillas, opposed to South Africa's continued occupation of the country (now called Namibia). SWAPO used neighbouring Angola as its power base, so most SAAF raids, known colloquially as 'externals', were made into Angola, which opposed the raids with mostly Cuban troops and equipment. The first Buccaneer action came during the paratroop assault on the Angolan mining town of Cassinga, a SWAPO stronghold. Most 'external' missions were flown from the base at Grootfontein in South West Africa.

Angola was to receive ever more sophisticated equipment, requiring the Buccaneers to adopt radar warning receivers and employ new tactics.

S.Mk 2 into service

Left: This No. 801 Squadron S.Mk 2 demonstrates the Mk 20 refuelling pod during a low-speed flypast. 801 took the S.Mk 2 to sea for its first operational cruise in 1966.

From the flight of the first production aircraft in June 1964, service entry of the S.Mk 2 was made rapidly. Production was undertaken at a high rate to enable all three front-line units earmarked for the variant to be fully equipped by February 1967. No. 801 Squadron led the way, and nine months after formation it embarked in *Victorious* for the variant's first fully operational cruise. The extra power of the Mk 2 was welcomed by flight crews who no longer had to endure the terror of a catapult launch in the woefully underpowered Mk 1.

The South African Buccaneer had earlier established an endurance record which is believed never to have been bettered, when Mike Muller (later SAAF Chief of the Air Staff) flew an S.Mk 50 for 9 hours 5 minutes on 13 December 1966, with the aid of two inflight refuellings. Attrition had reduced the SAAF fleet to six by 1979 and it is likely that the continuing operation of such an ever-diminishing fleet was a major factor leading to their official retirement on 30 June 1991, when just five examples remained flyable. Photographic evidence from early 1991 shows three of the survivors as 414, 416 and 421.

Royal Navy S.Mk 2 service

No. 801 Squadron had the task of bringing the Buccaneer S.Mk 2 into full squadron service. A short work-up cruise in home waters and in the Mediterranean was achieved in HMS *Victorious* over a three-week period from 14 May 1966. In June 1966, a squadron S.Mk 2 gave an indication of the type's potential when it launched from HMS *Victorious* in the Irish Sea and made a simulated low-level attack on Gibraltar airfield, to return to the carrier after a round trip of 2,300 miles (3700 km).

When embarked, the Buccaneers of No. 801 Squadron carried HMS *Victorious*'s tailcode 'V'. (At the time, the Royal Navy possessed four fixed-wing carriers – HMS *Ark Royal* 'R', *Eagle* 'E', *Hermes* 'H' and *Victorious* 'V', with *Centaur* 'C' in reserve, plus commando carriers *Albion* 'A' and *Bulwark* 'B'.) An example of coding of an early No. 801 Squadron S.Mk 2 was XN980, which carried nose code '233' and base (carrier) tailcode 'V'. Royal Navy tradition has it that nose codes ending in '8' or '9' are not used by aircraft operating at sea; as such, they may only be carried by permanently shore-based aircraft.

A major Far East cruise by HMS *Victorious*, with No. 801 Squadron embarked as part of the air group, commenced in July 1966. During the 12 months that followed, *Victorious* made three shore calls at Changi. During the initial moves over the withdrawal from Aden, the carrier operated for three days in early May 1967 in company with HMS *Hermes*. During this time the two air groups – their Buccaneers and Sea Vixens – and the RAF's Hunters from Khormaksar put up a 55-aircraft flypast as a show of strength. In the event, this was to be the carrier's last cruise. Although scheduled to remain in service until 1969, *Victorious* was probably too small to operate a realistic number of Spey Phantoms, and the government of the day was planning the run-down of the Navy's carrier fleet. When, in November 1967, a fire broke out aboard *Victorious* while the ship was undergoing refit, the decision was taken – almost arbitrarily – to withdraw it from service immediately. HMS *Victorious* saw no further use, and was cut up at Faslane in 1969. No. 801 then transferred to HMS *Hermes*, but only embarked on one major cruise in its remaining time with the Buccaneer, finally disbanding on 21 July 1970.

In 1966 the Wilson government had announced that plans to build CVA-01 would be cancelled, and that Britain's far-flung defence responsibilities could better be met by an RAF purchase of 50 F-111Ks, operating from land bases (although which land bases in particular was far from clear). Only *Ark Royal* was to be refitted to operate the Spey Phantom, with the whole of the carrier force due to be phased out by 1974/75. The early demise of HMS *Victorious* left the Navy with just three fleet carriers, and the Navy's requirement for fixed-wing carrierborne aircraft suddenly seemed to be very short-term.

Above: Just four days after its formal commissioning, No. 801 Squadron was tasked to provide this aircraft for the Trafalgar anniversary flypast over London. Early S.Mk 2s were delivered in this eye-catching grey/white scheme which introduced a new demarcation line.

Left: Following the fire during refit on* Victorious*, No. 801 Squadron was reassigned to* Hermes*. The tail marking combined the carrier's deck code ('H') with 801's winged trident badge.

Second front-line squadron

The second FAA Buccaneer S.Mk 2 squadron to reform was No. 809, which re-emerged in January 1966 when the first S.Mk 2 deliveries were made to it at Lossiemouth. Formal recommissioning took place on 27 January 1966 and the squadron quickly set about working up on the new variant. Public awareness of the S.Mk 2 as an operational type was heightened at that September's Farnborough air show, when the Navy staged a mass flypast of the four squadrons from HMS *Hermes*. No. 809 Squadron operated

While No. 800 Squadron continued with its S.Mk 1s until later in the year, No. 809 Squadron was established in early 1966 as the second S.Mk 2 squadron, assigned to* Hermes*. Codes assigned were H/320 to 327.

Above: 736's S.Mk 2s mostly served in the all-over grey scheme, and in later years featured the squadron badge (an eagle superimposed on a lightning bolt) on the fin. This example carries a pair of 2-in RP pods.

Above right: S.Mk 1s remained in use as trainers with 736 Squadron until the end of 1970, when the variant was hastily withdrawn. This example, seen in 1967, flies alongside a quartet of Hunters from No. 764 Squadron, the Navy's weapons training unit, co-located at Lossiemouth.

Seen during a cruise in the Indian Ocean in 1971, an 800 Squadron 'Bucc' refuels a rocket-armed Sea Vixen FAW.Mk 2 of No. 899 Squadron.

temporarily from RNAS Yeovilton for the event and launched six Buccaneer S.Mk 2s to fly alongside three Gannets, 10 Sea Vixens and five Wessexes from the other squadrons.

Assigned to *Hermes*'s air group and thus allocated the tail-code 'H', No. 809 was planned to deploy aboard *Hermes* for a Far East cruise, sailing in January 1967. The imposition of an airspace restriction by Spain on aircraft operating from Gibraltar's airport made necessary a 'show of strength', and *Hermes* spent some time patrolling around Gibraltar and the Spanish coast before sailing east. This event also put into perspective No. 801's simulated strike on Gibraltar (whose small land mass borders Spain) the previous June, underlining the Navy's ability to deploy air power and attack 'where needed' from its (admittedly ever-decreasing) force of aircraft-carriers. Although shore-based for 15 months from February 1968, No. 809 Squadron was subsequently allocated to HMS *Ark Royal*'s air group, with which it remained until disbandment, taking up the carrier's tailcode 'R'.

S.Mk 2s for training

Also receiving the S.Mk 2 in 1966 was No. 736 Squadron, the second-line training unit – effectively the Navy OCU – at RNAS Lossiemouth, which took delivery

Right: An 809 'Bucc' flies a practice approach to Hermes. On the carrier's side is the mirror landing system.

Far right: An 809 Squadron S.Mk 2 launches from the port catapult of Hermes. The squadron undertook cruises on three of the four Buccaneer-operating carriers.

Royal Navy training

In the S.Mk 1 period Buccaneer training had been the province of No. 809 Squadron, but with the arrival of the S.Mk 2 the unit was renumbered as No. 736 Squadron in March 1965 ('7' being the standard first digit for Fleet Air Arm second-line units). Initially allocated S.Mk 1s, the Mk 2 became available for training from May 1966. In addition to Royal Navy crews, No. 736 also trained SAAF crews and, later, the first RAF personnel. In the absence of a twin-stick Buccaneer, much use was made of Hunters in the conversion process.

of its first example of the new mark (XT284) on 9 May. The unit's S.Mk 2 strength increased steadily, reflecting the growing need to produce or convert pilots and observers to the S.Mk 2 as the squadron build-up continued. S.Mk 1s and S.Mk 2s continued in use together on No. 736 for some years, to peak at eight S.Mk 1s and 12 S.Mk 2s in 1970. No. 736's training throughput was steady during the mid- and late 1960s.

All was not totally well with the S.Mk 2's service introduction, though, and the Navy suffered its first S.Mk 2 loss when XN979 of No. 801 Squadron crashed into the sea off the Lizard, Cornwall on 9 June 1966. The recovery of the aircraft from a great depth at sea aided the post-crash analysis, but Boscombe Down still believed that pilot error – the sin of not following the laid-down take-off procedures – was the cause. An A&AEE test pilot sent to prove the point had the ignominy of crashing in very similar circumstances following launch from a carrier deck on 6 October 1966 (in No. 801 Squadron S.Mk 2 XV153 V/232), his flight lasting no more than 20 seconds.

Subsequent investigation by Hawker Siddeley at Brough determined that the critical condition following catapult launch had arisen as a result of a pitch-up and stall, caused primarily by an aerodynamic condition with the underwing tanks and stores. It was cured by a number of changes. A revised fairing was fitted between the fuel tank and the wing, which caused more drag but allowed the inner-wing blow to function more effectively; a more accurate tailplane position indicator was incorporated; and a revised attitude display was fitted to the OR 946 IFIS display. The tail trim settings for launch were revised and the handling drill on launch was changed, with the landing gear being left down until after the pilot had taken control, rather than (as previously) being selected up immediately prior to a deck launch via the deck take-off button. (This withdrew the solenoid

In the conventional attack role the Buccaneer could carry up to eight 1,000-lb (454-kg) bombs, four stowed internally and four on the wing pylons. A maximum drop of inert weapons is demonstrated by an aircraft of No. 800 Squadron.

which prevented the up button from being selected on the ground; nothing happened while the aircraft was on the deck and the oleos compressed, but the gear came up as soon as the aircraft was fully airborne.) These actions went a long way towards preventing pitch-up, although a former pilot recalls that – under certain conditions of configuration and launch speed – a catapult launch could still be 'very twitchy'.

Completing the re-equipment of the FAA's three front-line Buccaneer S.Mk 1 squadrons, No. 800 received its first S.Mk 2 (XV156) in early September 1966, occurring less than a month after the end of its activity with the S.Mk 1. By 10 February 1967, the squadron had received a complement of eight S.Mk 2s, and was declared operational on the new variant. Strength built up to 12 aircraft, and the squadron was again assigned (as it had been with the S.Mk 1) to HMS *Eagle*, carrying tailcode 'E'.

Grounded tanker

FAA Buccaneers were given the chance to show their prowess in the anti-shipping role by a quirk of fate. On 18 March 1967, the 118,000-ton tanker *Torrey Canyon* went aground close to Land's End, Cornwall, its cargo of oil posing a major pollution hazard. When the ship broke its back and oil started pouring into the sea, the government decided to use the Navy's Buccaneers to attack the ship with the aim of releasing the oil (but not necessarily of sinking the ship). First to attack, on 28 March, was a force of eight Buccaneers from Nos 736 and 800 Squadrons, operating from Lossiemouth with 1,000-lb free-fall bombs. Academic attacks – initially using 20° manual depressed line of sight attacks – were employed by the Buccaneers. Of the 42 bombs dropped, some 30 hit the *Torrey Canyon*, but the oil proved hard to persuade to burn. Two more Buccaneer attacks, supported by napalm and incendiary-bombed Hunters and Sea Vixens, were required before the ship finally succumbed and sank beneath the waves, all oil leakage seemingly having ceased. This had been an instructive operation for Royal Navy planners; the Buccaneers did all that was asked of them, but the operation was ultimately unsuccessful, as the oil did not burn as expected.

No. 800 Squadron duly embarked in HMS *Eagle*, starting with the normal shake-down cruise in home and Mediterranean waters in June/July 1967. On 15 August 1967, *Eagle* set sail for a 10-month cruise to the Far East, involving forming part of the task force assembled off Aden in November that year to cover the withdrawal of British forces from the area, with three periods ashore for No. 800's Buccaneers. Although a refit undertaken in late 1968/early 1969 had included the modification required to allow *Eagle*'s catapults and arrester gear to operate the upcoming Phantom FG.Mk 1 – and despite 81 successful touch-and-go landings made by the type in March 1969 – the government decreed that *Eagle* had no future, and that the cost of refitting it to operate the Phantom would be prohibitive. Thus, *Eagle*'s active career came to an end

S.Mk 2s in action: above, an 800 Sqn aircraft launches while* Eagle *raises liquids from RFA* Olna*; at right is an aircraft from 809 Sqn aboard* Hermes*, to which the squadron was assigned for two cruises; below is another 800 aircraft, seen carrying practice bombs.

Torrey Canyon

On 28 March 1967 the Buccaneers of Nos 736 and 800 Squadrons attacked the grounded tanker *Torrey Canyon*, with the aim of breaking up the ship so that the oil would escape, whereupon it could be ignited. The first mission was flown in some hurry, to the extent that aircraft departed Lossiemouth with incomplete bomb loads and were inflight refuelled by other Buccaneers on their way south. Both S.Mk 1s and S.Mk 2s were used. Operations continued throughout the next two days, using Brawdy as a staging post.

Above: Five 800 Squadron aircraft and three from 736 are seen being bombed up during the* Torrey Canyon *attacks.

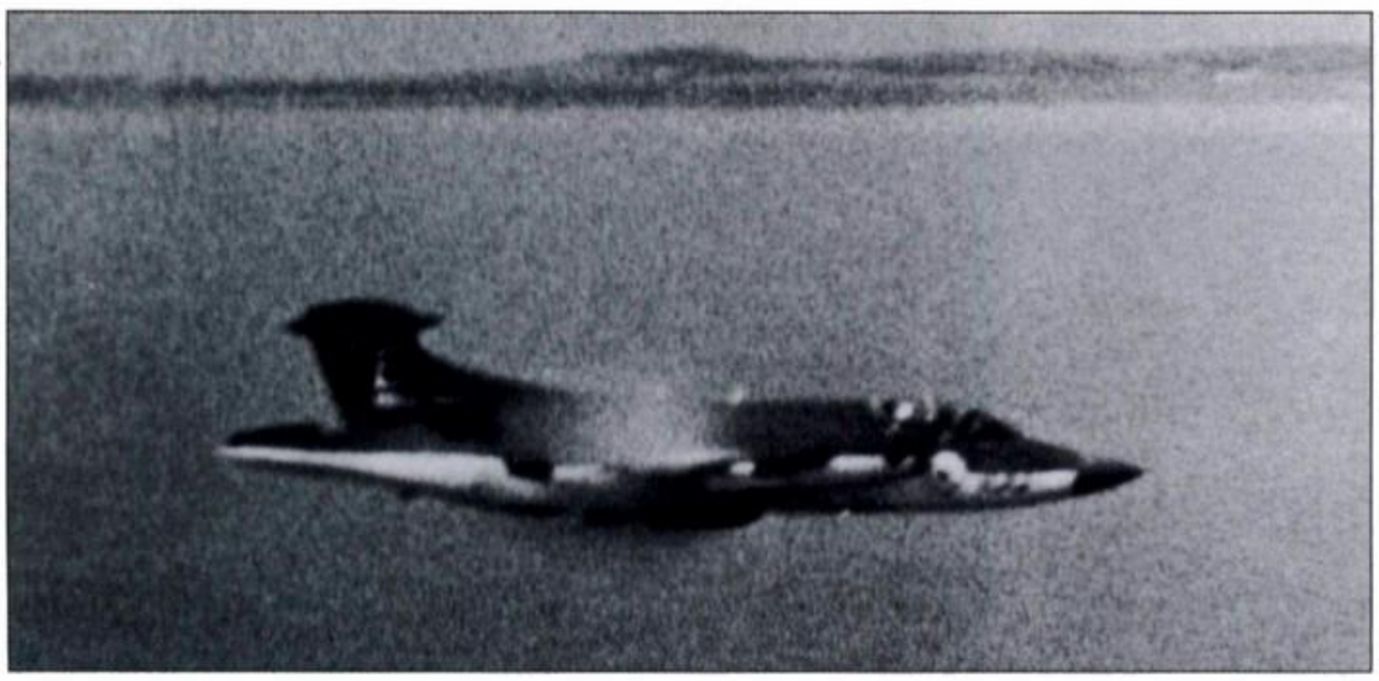
Left:* Torrey Canyon *is seen on 30 March, having suffered numerous hits from Buccaneers. The funnel strike was the work of Lt J. Tod and his RAF exchange observer, Flt Lt G. Pitchfork, on the last of the first day's attacks.

Red Beard

Following the termination of the Fairey guided nuclear bomb programme (Green Cheese), the free-fall tactical weapon Red Beard was left as the Buccaneer's primary armament. Developed to meet Operational Requirement (OR) 1127, Red Beard was a tactical weapon initially developed for service with the Canberra fleet and as a partial replacement for the Blue Danube weapon carried by the first V-bombers. Alternative names were the 2,000-lb TM (Target Marker) or simply 'the kiloton weapon'. With a yield of 15 kT, the warhead was tested in Operation Antler at Maralinga in August to October 1957, involving three detonations (two tower-mounted and one suspended under a balloon). Red Beards were fielded on the Canberras of the Akrotiri Strike Wing, on Royal Navy Scimitars from 1963 (as an emergency measure pending full introduction of the Buccaneer) and with the V-force, in the latter case primarily for the Valiant, which could carry two, but also as a Vulcan/Victor 'top-up' measure until sufficient Yellow Sun megaton weapons became available. Red Beard was by today's standards a primitive weapon, with no inflight loading facility. Consequently, once it was on board the Buccaneer it was live. Fusing and delivery options were limited. However, unlike that of other UK weapons of the time, all fissile material was removable, allowing it to be stored separately from the bomb. Red Beard was withdrawn from service around 1969/70 in favour of WE177A.

Left: A No. 801 Sqn S.Mk 2 releases a '2,000-lb shape'. Level bomb drops were tested at various speeds, although the preferred delivery technique was a toss. Note the pop-out fins.

Below: Red Beard was carried on a special bomb door with aerodynamic fairings. Attaching the weapon to a standard bomb door had resulted in serious aerodynamic buffet.



Although poor in quality, this photograph nevertheless depicts a No. 800 Sqn S.Mk 1 undertaking a Red Beard 'shape' drop at the West Freugh range. Running in at low level, the Buccaneer would pull up for either a toss or over-the-shoulder delivery.

A No. 803 Squadron aircraft lands on HMS Hermes in August 1968 during Exercise Bobbin Plus. This operation demonstrated the ability to rapidly deploy Buccaneers to carriers sailing in the Far East.

when it returned to Portsmouth from the Far East on 23 January 1972. With its carrier consigned to be scrapped, No. 800 Squadron disbanded for the last time as a Buccaneer unit on 23 February 1972. The squadron's aircraft were in general reissued to the RAF; an example was XV336, which was flown from Lossiemouth to Honington on 24 April 1972, for servicing and incorporation of RAF modifications (including the removal of the underwater ejection system). After being locally repainted in RAF colours, it was issued to No. 12 Squadron in November of that year.

The fifth and final Fleet Air Arm S.Mk 2 squadron was No. 803, which was formed on 3 July 1967 at Lossiemouth as the Buccaneer Headquarters Squadron. Although numbered in the '800' series, No. 803 had no assigned air group and its aircraft carried the Lossiemouth 'LM' tailcode. Its purpose was to carry out weapons trials and avionics testing, in which role its aircraft were engaged throughout the squadron's short existence. The squadron initially had four pilots and two observers, plus a weapons system engineer. It undertook trials on the Buccaneer's weapons systems, and developed attack modes (including locked-on dive toss and radar ranging depressed sight line) using mainly the ranges at Tain and West Freugh. In a moment of high visibility, the squadron did fly onto HMS *Hermes* in the Indian Ocean in August 1968, four aircraft departing Lossiemouth in the company of two Victor tankers and completing the deployment in less than 18 flying hours and four days. This demonstration of rapid deployment, which took place as part of Exercise Bobbin Plus, was perhaps the highpoint of No. 803's period with Buccaneers.

The fire in *Victorious*, which precipitated the run-down of the carrier force, not to mention financial strictures, had caused the Royal Navy to show only polite interest in more advanced developments of the S.Mk 2, including the Buccaneer 2* ('two star') proposals of 1965. Although unsuccessful in landing a development contract, the work done on the 2* at Brough did include the study of changes required for the Martel anti-ship missile (ASM), which would find its application later in the Buccaneer story.

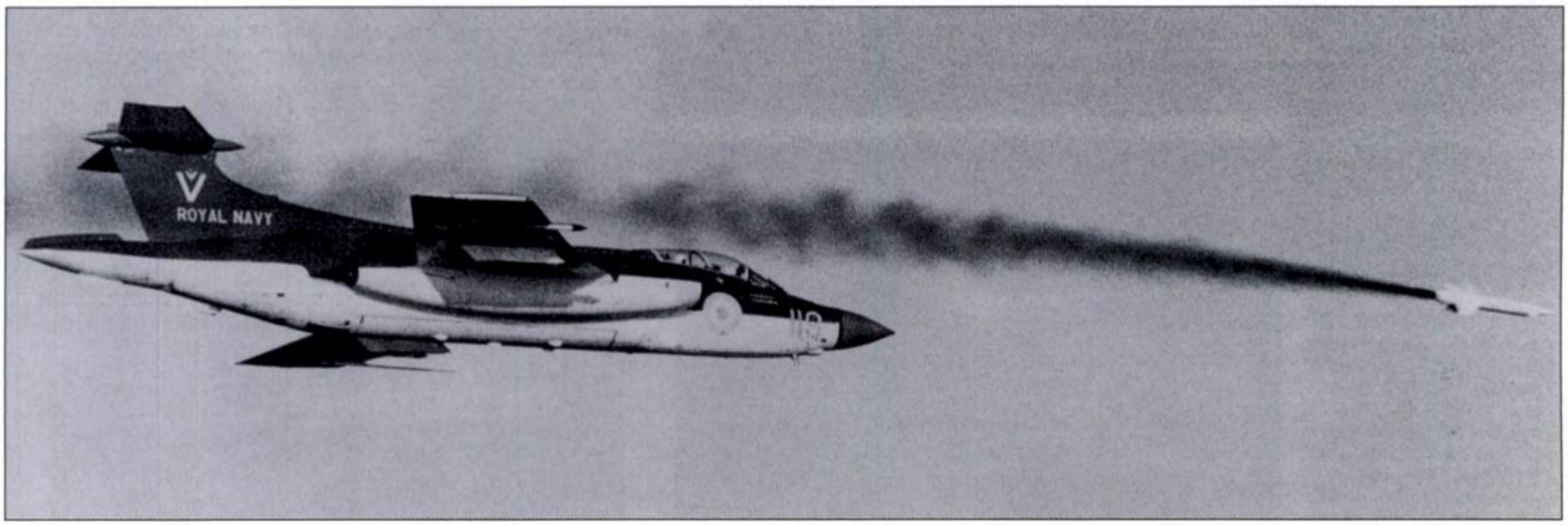
'But is it supersonic?'

On 16 January 1968 Harold Wilson announced the cancellation of the RAF's purchase of 50 F-111Ks. To say that this left RAF procurement policy in tatters is no understatement. ('To lose one supersonic low-level strike aircraft is unfortunate. To lose two smacks of a lack of policy.') Even so, it was July of the same year before a Royal Air Force order was announced for a batch of 26 new-build Buccaneer S.Mk 2Bs, to be based on the Navy S.Mk 2 but with improvements for increased range in the land-based role. The larger, 430-Imp gal (1955-litre) tanks

Bullpup

Precision attack capability for the Buccaneer was initially provided by the Martin Marietta AGM-12 Bullpup A missile, which was also procured for carriage by the Sea Vixen. The Bullpup A was built around a standard 250-lb (113-kg) bomb warhead and featured four small delta control fins and four large aft wings. A liquid propellant rocket motor provided a range of about 4½ miles (7 km). Guidance was effected by radio command by the Buccaneer's observer, having centred his sight on the target before launch. Flares in the rear of the missile allowed the observer to follow it visually, supplying mid-course control inputs as required. The missile had a length of 10 ft 6 in (3.2 m), body diameter of 1 ft (0.305 m) and a wing span of 3 ft 1 in (0.94 m). The launch weight was 569 lb (258 kg). The much larger Bullpup B, based on a 1,000-lb (454-kg) bomb or a 15-kT nuclear warhead, was not procured by the Royal Navy.

Right: A No. 800 Squadron S.Mk 2 prepares to launch from **HMS Eagle**, *carrying two Bullpups on its inner pylons. Up to four missiles could be carried on the wing pylons.*



as fitted to the S.Mk 50 were an obvious choice, given the removal of the carrier launch weight constraint, and a new underwing pylon fit, as developed for the earlier 2★ and P.145 proposals, was agreed upon. The RAF requirement was to accommodate a larger range of weapons, including Martel, while maintaining the reconnaissance capability involving a bomb-bay mounted reconnaissance pack.

2B or not 2B? Martel is the question

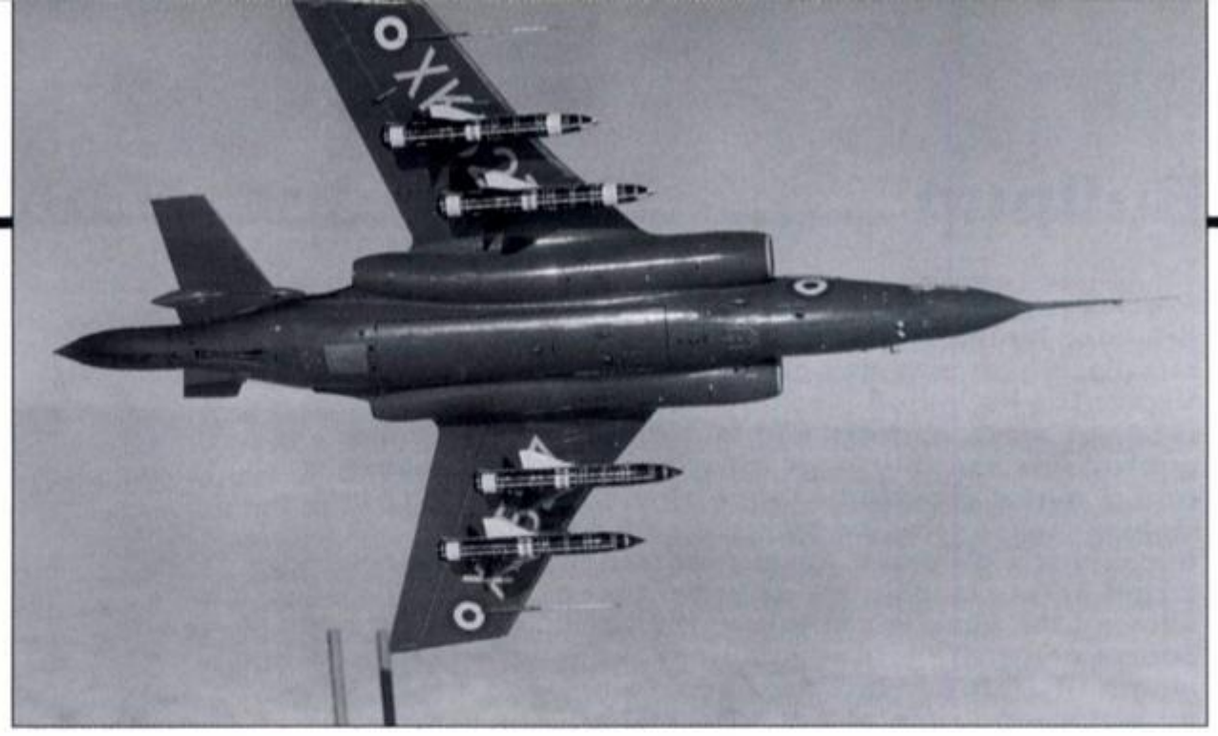
The Royal Navy had already decided to introduce the Martel on its own S.Mk 2s, and a programme to provide the necessary airframe and avionics changes had been instigated in September 1966. Martel, which existed in both TV-guided (AJ.168) and anti-radar (AS.37) versions, met the Navy's requirements for stand-off attack and radar suppression, respectively, and the missile was adopted despite the short remaining projected service life of the S.Mk 2. The existing pylon arrangement had to be changed to allow the carriage of Martel, and the wing-fold mechanism updated to handle the load of a Martel missile on the outer wing. Both two- and four-Martel schemes were studied, the former having the attraction of a lower conversion cost, but eventually the full four-missile fit won the day. One advantage of this fit was that the new pylons could, with triple ejector racks, permit the carriage of three 1,000-lb bombs on each station. The observer's cockpit had to be modified to fit the display screen for the TV version, the equipment having been developed for the cancelled

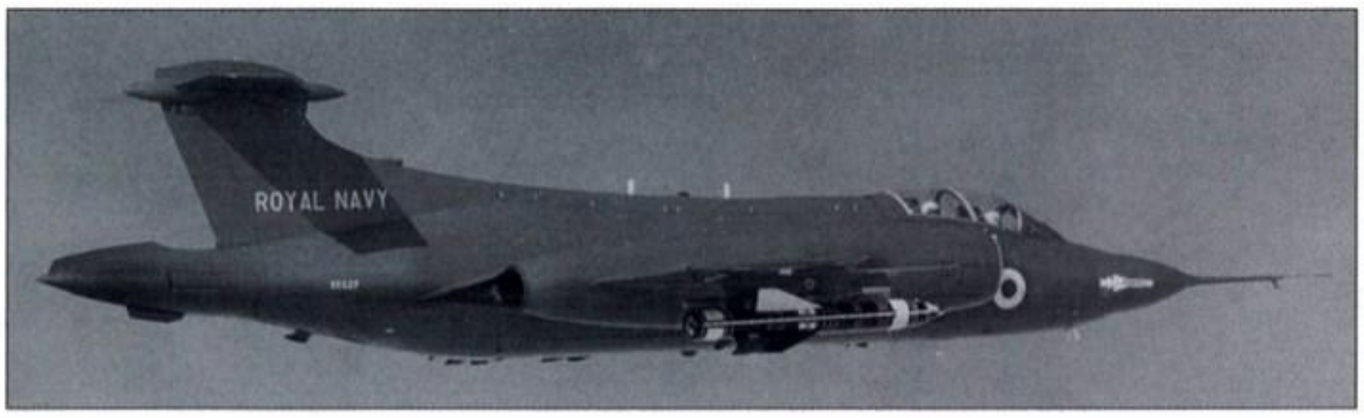
S.Mk 1s were converted to carry the Bullpup under Mod 5031. Here the launch aircraft is from No. 801 Squadron. Although many firing trials were undertaken, the Bullpup never proved to be accurate or reliable, and consequently it did not figure prominently in the Buccaneer's day-to-day operations.

Buccaneers saw service from a total of four carriers.* HMS Victorious *(from the 'Illustrious' class) was the first to be retired, having suffered a major fire during refit in 1967.* Hermes *(class leader) was converted to a commando carrier in 1970, leaving the two 'Ark Royal'-class vessels to sail into the 1970s. Of these,* Eagle *survived until being paid off on 26 January 1972 (and subsequently scrapped), with* Ark Royal *continuing until a similar fate befell it on 4 December 1978. Here the Buccaneers of 809 Squadron share* Ark Royal*'s deck with No. 892 Squadron Phantom FG.Mk 1s.

Martel trials

The fitment of Martel capability to the Buccaneer, while producing a far more capable aircraft in terms of precision strike capability, did require a major rework of the wing in order to carry the missile. Various structures were strengthened and the wings reskinned. New pylons of a longer, shallower nature were fitted. Inside the cockpit a TV display screen and hand controller were added, an installation which required modified ejection seats. The manufacturer's workhorse, XK527, flew many of the early tests, supported by the first production S.Mk 2 (XN974) and the first RAF aircraft (XV350). XK527 was deployed to *Ark Royal* for an intensive series of 67 carrier landings with the missile, flown by HoSM's Derek Whitehead and Mike Nicholl, and by a crew from the A&AEE's RN Test Squadron. The RAF achieved Martel capability first, and it was not until October 1973 that the Navy's No. 809 Squadron received Martel-capable S.Mk 2Ds.





Above and top: Test workhorse XK527 was used for much of the Martel pylon and carriage clearance work. Here it is seen carrying four of the anti-radar version.

Right: Navy aircraft with Martel capability (Mod 1168) were designated (after 1972) S.Mk 2D. This No. 809 Squadron example carries a single TV Martel along with the accompanying datalink pod. Note the 'prong' antennas for the ARI18218 warning receivers mounted under the outer wings.

Far right: Steam rises from the deck milliseconds before the catapult strokes this 809 Squadron Buccaneer into the air. The small pimple visible just forward of the nosewheel bay originally housed a weapons recording camera, but this was little employed and was usually removed altogether.

F-111K. Once agreed and funded, the programme proceeded quickly. S.Mk 1 XK527 was used to clear the pylon arrangement and to perform initial test firings, while S.Mk 2s XN974 and XV350 – both of which spent the whole of their active lives on trials work – took part in trials of Martel and other weapons with the new pylons. The airframe modification involved putting the wings back into jigs, the fitting of new, larger pylons, reskinning and the incorporation of various structural changes, these changes being incorporated under Mod 1188. Royal Navy S.Mk 2s reworked to be Martel-capable were designated S.Mk 2Ds; other Navy aircraft having received a more basic package of avionics modifications became S.Mk 2Cs.

The Martel-compatible pylons of the S.Mk 2B and S.Mk 2D are recognisable by being longer and shallower than the 'pre-Martel' pylons. New-build RAF aircraft (with inbuilt Martel compatibility) were designated S.Mk 2B, while non Martel-compatible Navy aircraft transferred to the RAF and receiving a package of modifications to meet RAF requirements became S.Mk 2A. At this point, the S.Mk 2 designation remained only for the basic Royal Navy aircraft as delivered.

Along with the decision to purchase new-build Buccaneer S.Mk 2Bs for the RAF came the agreement to hand over the Fleet Air Arm's inventory of Buccaneer S.Mk 2s, as the Navy squadrons ran down and disbanded. Although this was to mean the end of all Navy Buccaneer operations by the mid-1970s – a date which moved continually – it led, in the short term, to a period of increased activity for the Navy's OCU, No. 736 Squadron. Over the following 10 years, 64 of the 84 S.Mk 2s delivered to the Fleet Air Arm were passed to the RAF, in whose service they eventually became – after modifications – S.Mk 2As or S.Mk 2Bs.

This designation scheme – which sub-classified S.Mk 2s into S.Mk 2A, S.Mk 2B, S.Mk 2C or S.Mk 2D – was seemingly introduced only in 1972. Prior to this, Navy aircraft had been simply designated S.Mk 2 and RAF new-build Buccaneers S.Mk 2B. Thus, any references to (especially) S.Mk 2A before 1972 should be considered effectively retrospective.

Vapour boils above the outer wings (energised by the vortex-generating vanes), under the tailplane and from the practice bomb carriers as a No. 809 Squadron Buccaneer makes a low-level run. The 'Bucc' excelled at this sort of flying, proving exceptionally stable and comfortable at high speed and low level. Although no terrain-following equipment was fitted, the Blue Parrot could give rudimentary terrain warning, and the autopilot had a radio altimeter height-hold function.

Ex-Navy S.Mk 2s, S.Mk 2Cs or S.Mk 2Ds were eventually denavalised and fitted with the RAF modification package for their transfer. Navy-specific items – deck take-off hooks to attach the bridle, hold-back gear and underwater ejection (in which two compressed air bottles were fitted to the seat, with an ejection sequence involving canopy breakers and the use of compressed air to free the crew member from his seat, inflate his life jacket and – hopefully – cause him to rise to the surface) – were removed at this time. Some ex-Navy aircraft, though, were transferred to the RAF and then back to the Navy, to deploy with No. 809 Squadron aboard HMS *Ark Royal* in its final years. XN983 was one example. Transferred to the RAF and No. 12 Squadron as an interim S.Mk 2B on 22 July 1970, it was converted to full S.Mk 2B standard at Sydenham by 29 August 1972. It had joined No. 237 OCU as an S.Mk 2B by November 1972, but returned to HoSM and Brough on 17 July 1973 for a retrofit to S.Mk 2D standard. It then spent a period with No. 809 Squadron, before returning to the RAF by 1976. While ex-Navy aircraft could be modified – and demodified – in this way, RAF new-build S.Mk 2Bs were not carrier-capable, as they had not been built with the fittings for deck take-off.

Fly Navy – the RAF accepts the challenge

In the latter years of Fleet Air Arm Buccaneer operations, a significant proportion of aircrew was provided by the RAF, on loan service. These aircrew, perhaps attracted by the Navy life or the undoubted challenge of fast-jet

First for the RAF

Prior to the delivery of new-build S.Mk 2Bs, the RAF received ex-Navy aircraft in two distinct sub-variants. The first were aircraft given the RAF-specific Mod 1499 improvements, but lacked Martel capability (S.Mk 2A). Others had Martel capability (Mod 1188) but did not have the RAF modification. These aircraft were later mostly upgraded to full S.Mk 2B standard (Mods 1188 and 1499).

Above: A bombed-up 809 Squadron S.Mk 2D is caught at the moment of launch from* Ark Royal. *In order to achieve sufficient wing incidence for launch from the short catapult, the Buccaneer was positioned in a nose-up attitude by the use of a hold-back. The launch was made 'hands-off' to avoid the pilot pulling back on the stick too far at a critical moment.

Far left: An S.Mk 2D is seen just after hooking on 'Ark' during joint operations with HMS* Fearless. *XV869 was the last Buccaneer manufactured for the Navy.

XV350 was the first aircraft to emerge from Mod 1499 and was thus the first S.Mk 2A (although not known as such at the time). It was also the first machine handed over to the RAF, on 1 January 1969.

The first four Buccaneers delivered to an RAF squadron arrived at RAF Honington on 1 October 1969, the lead aircraft being flown by No. 12 Squadron's commanding officer, Wing Commander G. Davies, AFC. The aircraft were ex-Navy machines refurbished to an interim Air Force standard.

Blackburn Buccaneer

Right: An unusual sight was an S.Mk 1 in full RAF markings. This aircraft, XN956, had seen front-line service with Nos 800 and 801 Squadron, and then use as a trainer by No. 736 Squadron. In its new scheme it was ferried to Laarbruch for battle damage repair training.

Above and far right: As part of the slow transfer of Buccaneer operations from the Navy to the Air Force, 237 OCU was established in March 1971 to handle Buccaneer training for the RAF, assuming the Royal Navy training commitment a year later. The initial equipment consisted of non-Martel S.Mk 2As, although these aircraft were subsequently upgraded to full RAF standard in the mid-1970s. In the early years of its existence the OCU had a standard wartime role of supplying crews (comprising instructors) and aircraft to bolster the front-line force, but later was assigned a specialised laser designation war role.

operations from a carrier, typically did one tour only with the Navy, although some later returned to No. 736 Squadron as instructors. Their early introduction to the aircraft and subsequent experience were later to prove invaluable, providing the cadre for the RAF's Buccaneer operations.

With no new-build RAF aircraft yet produced, the job of training the RAF's first crews was inevitably given to the Navy and No. 736 Squadron. An RAF cell was formed on No. 736 in spring 1969, with three pilots, two BAIs (Buccaneer Attack Instructor – the term QWI came later), one QFI and three navigators. All were RAF officers, but had previously flown the Buccaneer with FAA squadrons. The task was to run eight RAF courses, each of four crews, to convert pilots and navigators to the Buccaneer. (Important note – backseaters were termed observers in Navy, but navigators in the RAF, and navigators/weapons systems officers in the SAAF). Because of the scarcity of S.Mk 2s, a number of S.Mk 1s were taken from their recent retirement to supplement the S.Mk 2s. Students for these courses – RAF Courses 1-8 – came from a variety of backgrounds: some had Canberra, Hunter or V-bomber experience, while others were *ab initio*. RAF courses initially used the S.Mk 1 only, with three final course sorties being allocated to convert to the S.Mk 2.

The Buccaneer S.Mk 1's service career came to an abrupt end in late 1970. On 1 December, an instructor was in the back seat of S.Mk 1 XN951, with a student pilot on his first sortie. On the second circuit of Lossiemouth, the port engine surged; at this altitude, and with the aircraft badly positioned for landing, ejection was the only course. One week later, on 8 December, a student sortie in XN968 suffered an uncontained turbine failure, which again left the crew with no option but to eject. Although within the parameters for a successful ejection, the seat's scissor shackles of the observer's seat were jammed by a piece of Perspex (no Miniature Detonating Cord/MDC was fitted to the S.Mk 1) and the occupant was unable to separate from the seat, and was killed. Closer examination of the remaining S.Mk 1s' Gyron Junior engines showed them to be in a bad state, and the decision was taken immediately to ground the S.Mk 1.

This had only a limited effect on No. 736, since it was near the end of its RAF training task, with No. 7 Course scheduled to graduate in March 1971. The last S.Mk 1 was flown out in January 1971, and the remaining training was undertaken solely on the S.Mk 2. To help out, a number of RAF Buccaneers, including XV157 and XV349, were sent to Lossiemouth for the period January-March 1971. Events conspired to make No. 7 Course the last to be run at Lossiemouth; No. 8 – a 'short' course for experienced aircrew – was rescheduled to run concurrently with No. 9 Course at RAF Honington starting in May 1971 (see later).

An RAF officer in tropical kit inspects a No. 12 Squadron Buccaneer during a visit to Akrotiri. The aircraft demonstrates the powered wing-fold mechanism which was retained by even the new-build RAF Buccaneers (although all carrier equipment bar the arrester hook was deleted). It is armed with 18-round SNEB pods. The gloss paint and high-visibility Type 'D' roundels in which the Buccaneers were originally delivered to the RAF made the aircraft look pristine, but soon gave way to matt paint and Type 'B' roundels.

First RAF aircraft – and first RAF squadron

The graduating crews were destined for the first two RAF squadrons, and RAF Honington was designated the UK Buccaneer operating base. New-build S.Mk 2Bs were on the line at Brough, and were allocated serials XW525-XW550, with no blackout blocks.

With the continuing rundown of FAA squadrons, a few ex-Navy S.Mk 2s became available, and were given a number of modifications to meet RAF requirements. The changes, incorporated under Mod 1499, were not extensive, and centred around the electrical system and the fitting of modified, uprated brakes with metal-to-metal contact (as developed for the S.Mk 50). Ex-Navy S.Mk 2s which received Mod 1499 were – or would become, when the designation was officially applied – S.Mk 2As. Other ex-Navy aircraft received the pylon modifications to become Martel-compatible (Mod 1188), but lacked other RAF-specific changes. These modified aircraft – which

Marked with No. 16 Squadron's well-known crossed keys and 'Saint' marking, this is one of the unit's early Buccaneers (left). It had previously flown with No. 12 Squadron. The immediate area around the base at Laarbruch was on the Rhein floodplain. By contrast, the Eifel mountains and Mosel valley (below) were not far away, providing some useful low-level training terrain.

were initially brought to approximately the build standard of the final Royal Navy S.Mk 2 batch XV863-XV869 – are best described (albeit unofficially) as 'interim S.Mk 2Bs'.

The first aircraft to be delivered to the RAF was XV350, which was nominally transferred on 1 January 1969 and which made its first flight, after modifications, on 11 February that year. While XV350 spent its remaining service life on trials, either at HoSM or Boscombe Down, a steady trickle of more S.Mk 2s made possible the formation of the RAF's first Buccaneer squadron, No. 12 – 'Shiny Twelve' – at Honington.

The camouflage scheme adopted was of semi-gloss dark sea grey and dark green upper surfaces and light grey undersides, with red/white/blue 'D'-type roundels, which was in line with the scheme used on Phantoms and Jaguars. No. 12's fox's head badge was soon displayed on the intake trunk of its Buccaneers, which were 'interim S.Mk 2Bs'.

No. 12 was allocated the maritime role and was SACLANT-assigned, with the intention that RAF Buccaneers would have to take over the role when the Navy's Buccaneer squadrons were disbanded upon the retirement of the last aircraft-carrier. This was scheduled to happen on the decommissioning of HMS *Ark Royal* and the disbandment of No. 809 Squadron, for which defence planning envisaged a date of 1974-75. Deliveries of ex-Navy Buccaneers continued, to give No. 12 Squadron its intended complement of 12 aircraft.

RAF Germany and QRA

Exactly one year later, on 1 October 1970, No. XV Squadron was reformed at RAF Honington to give the RAF its second Buccaneer unit. As with No. 12 before it,

RAF Germany

Nowhere were the Buccaneer's duties taken more seriously than in Germany, where the type sat nuclear alert for over 11 years. From 1976 operations were conducted from hardened aircraft shelters as the threat of air strikes with little notice was high. The Buccaneer handed over the strike mission to Tornados in 1984.

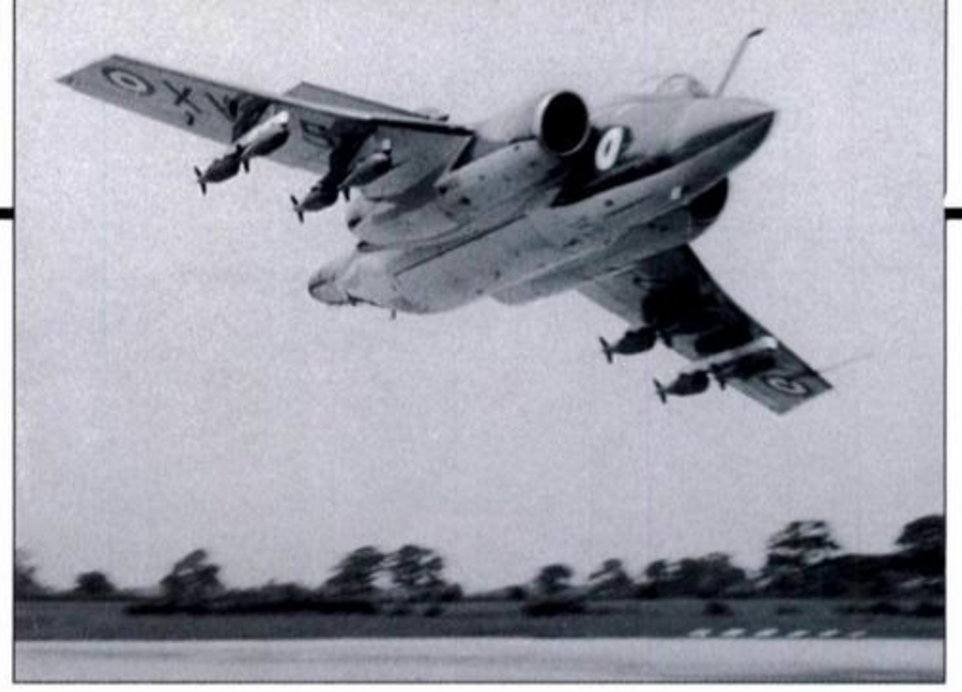
No. 15 had previously flown V-bombers. Unlike No. 12, the second squadron received new-build aircraft, in the form of S.Mk 2Bs from the Brough line, and XW526, the second production S.Mk 2B, became the squadron's first Buccaneer. Destined for RAF Germany to replace the ageing Canberra B(I).Mk 8s which provided the strike alert, No. 15 moved out to RAF Laarbruch in January 1971. It is not immediately clear why the squadron had priority on the

Below and below left: Three photographs depict RAF Buccaneers firing SNEB rockets. The SNEBs were more accurate and hard-hitting than their predecessor. SAAF Buccaneers used them for several anti-armour kills.

SNEB rockets

Initial rocket armament for the Buccaneer was the 2-in RP, but these gave way to the widely used 68-mm SNEB. They were carried in the 18-round MATRA 155 pod, which weighed around 410 lb (186 kg) when loaded. The SNEB was designed by TDA, and was very similar to the US 2.75-in FFAR, with eight flick-out fins for stabilisation. For fixed-wing use the rockets employed the Type 25 F1B motor with a variety of warheads. Each rocket was 3 ft (0.91 m) long and weighed 11 to 14 lb (5 to 6.4 kg) depending on warhead.

Blackburn Buccaneer



Above: The first RAF machine, XV350, was extensively used for testing new equipment for the force. Here it carries the Westinghouse ALQ-101(V)-10 jamming pod, which dramatically enhanced the Buccaneer's survivability after it entered service in 1976.

Right: XV350 again, this time seen testing the bulged bomb bay door tank in 1970. The installation imposed only a minor drag penalty. The tank made its appearance on service aircraft in 1974.

Top right: The tandem bomb carrier, developed for Navy use, was occasionally employed by the RAF. This offered a relatively low-drag carriage for 500-lb (227-kg) bombs, and is seen here under test on XV350.

Right and below: RN operations were moved to Honington in 1972. The RAF supplied some aircrew and aircraft to the Navy in this period, although only the aircraft originally built for the Navy were carrier capable, as the RAF's new-build S.Mk 2Bs did not have catapult attachment points.

new-build aircraft, although this may have been connected with modifications required in connection with the WE177 nuclear store, which was introduced on the Buccaneer from 1969, or with radar changes for the overland role.

Such was the state of anti-aircraft defences at medium and high level in Eastern Europe that any attack from Laarbruch would have to be made at low level. With such short transit times to the Inner German Border, the RAF Germany Buccaneer squadrons did not keep current in air-to-air refuelling, and probes were not fitted.

Delivery of the WE177 nuclear weapon, which was mounted on the centre, fifth, station in the bomb bay and surrounded by an aerodynamic fairing, was by either laydown or toss profiles. A modification to the S.Mk 2B introduced station 10, to allow the carriage of two WE177 weapons. These 'special stores' were long but not particularly wide, making possible their carriage side-by-side on the central stations in the bomb bay, with aerodynamic fairings at front and rear of the bomb bay door. The Buccaneer S.Mk 2B had nine or 10 weapons stations. Stations 1-4 were underwing, in the sequence (looking towards the nose, from left to right) 4 2 1 3, while 5-8 were the four bomb bay locations for conventional weapons and 9 and 10 were side-by-side at the centre of the bomb bay door, and were for 'special stores'. In the laydown delivery, a retarded weapon was employed, a parachute slowing the descent of the bomb to allow the aircraft time to egress. Laydown attacks were practised at Nordhorn – the RAF's own range in Germany – using 4-lb bombs. An alternative was a 'varitoss' delivery, which involved a low-level approach from the IP and a pull-up to 60° nose-up. The bomb was released automatically by timer, after which the pilot rolled to 150° of bank, and pulled back to return to low level and exit the area. Practice deliveries were regularly flown, most usually on the Vliehors range on the Dutch coast. The navigator performed his switch selection from the rear cockpit, to release a 28-lb bomb from a CBLS (Carrier Bomb Light Store – a practice bomb container) in the bomb bay, with a WRS (weapon response simulator) in the body of the CBLS simulating the responses from a real weapon.

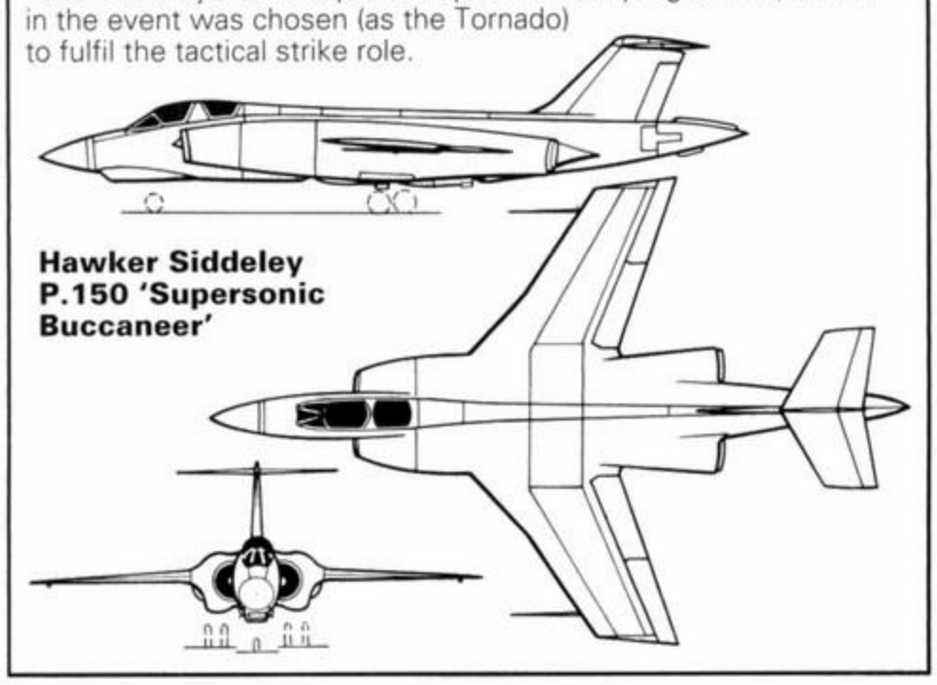
The Buccaneer's range allowed strike sorties with a clean aircraft to a radius of 400-500 miles (645-805 km) from Laarbruch, and empty drop tanks could have been jettisoned in a war situation, to increase range further. In the 1970s, West Germany's low-flying regulations were more liberal and permitted 250 ft (76 m) in low-flying areas and link routes, and 500 ft (152 m) almost anywhere. RAF Germany squadrons flew almost all their training at low level. The only exceptions were in the case of bad weather, when medium-level transits could be made to use the East Coast ranges in the UK before returning, unrefuelled, to Laarbruch. In several summers in the 1970s, a different kind of restriction was forced upon the squadrons by a proliferation of birds, whose north-south migratory routes crossed Germany. Taking into account the birds' weight and their penetrative ability, the Laarbruch Buccaneers were restricted for training sorties to 360 kt (414 mph; 666 km/h) at low level, rather than their more normal 480 kt (552 mph; 888 km/h).

Two-seat Hunter

As related earlier, there has never been a full 'twin-stick' (i.e., dual-control) Buccaneer. The Navy pioneered the use of the two-seat Hunter to fill this gap, after which a batch of two-seat Hunters was an essential requirement for Buccaneer conversion, instrument flying, training and periodic dual checks. Variants used included the RAF T.Mk 7A and the ex-Navy T.Mk 8B, both of which had IFIS (Integrated Flight Instrumentation System) fitted, which replicated the Buccaneer's flight instrumentation in the left-hand cockpit. Both variants had dual controls, and the only major differences were that the T.Mk 7A had ILS and the T.Mk 8B was hook-equipped. At Honington, the Hunters were on the strength of the OCU, but the based squadrons were allocated hours on the type for dual instrument rating checks, etc., as required. In Germany, each Buccaneer squadron had its own Hunters.

Supersonic Buccaneer

Two Buccaneer developments were offered to the RAF. The first was the P.145 (Buccaneer S.Mk 3), a modest improvement based on the S.Mk 50 but with Martel capability. Far more radical was the supersonic P.150 of 1968, which had a longer fuselage, new tail, afterburning Spey engines and bogie undercarriage. In July 1968 the UK joined the pan-European MRCA programme, which in the event was chosen (as the Tornado) to fulfil the tactical strike role.



Hawker Siddeley P.150 'Supersonic Buccaneer'

In RAF service the first task assigned to the Buccaneer was anti-shipping. This pair of early 'interim S.Mk 2Bs' of No. 12 Squadron is seen conducting maritime operations, armed with the original Navy 2-in RP pods.

For the public, the abiding memory of the Buccaneer is as an air show performer, the type's low-level characteristics being exhibited to the full by enthusiastic pilots. This hangar-height pass by a No. 12 jet was typical of the days before public safety concerns forced the aircraft to perform at greater heights.

At the time of the formation of No. 237 OCU in March 1971, RAF planning envisaged the formation of six front-line Buccaneer squadrons, to include three in the maritime role. In fact, despite a follow-up order in 1971 for a further batch of 16 aircraft, this total was never achieved; the UK's Buccaneer force peaked in 1978 at five front-line squadrons, including No. 809 Squadron aboard HMS *Ark Royal*. The new batch of Buccaneer S.Mk 2Bs was allocated XX885-XX901. They were the first built with a radar warning receiver in the fin/tailplane bullet fairing, but this equipment was retrofitted to earlier aircraft from 1975. The alert reader will notice that this serial batch totals 17 aircraft. The difference is represented by XX897, which was delivered to RRE Pershore on 15 April 1976 and was used for all its life on radar trials, and was thus funded under a different contract. With the peak of squadron formations by then over, XX885-XX901 were delivered at a somewhat slower pace than previously, between April 1974 and January 1977. Aircraft of a final batch of three (XZ430-XZ432) followed on, with XZ432 – the RAF's last Buccaneer – being delivered on 6 October 1977.

Mention should also be made of three Buccaneer S.Mk 2Bs ordered specifically for test purposes by the Royal Aircraft Establishment (RAE). XW986-XW988, which constituted the seventh production batch, were all delivered in the first half of 1974. Underlining their 'non-combat' status, they were initially finished in a high-visibility yellow, white and green photographic paint scheme, in which they flew on weapons trials, primarily from West Freugh, although they were nominally on the strength of RAE Farnborough. Many Buccaneers have been used at various times on test and development programmes but only these three and XX897 were actually ordered specifically for the purpose.

No. 237 OCU

Although the OCU was not yet at full aircraft strength, the first Long Course (No. 9) commenced in May 1971. A student pilot's first sorties were undertaken in a two-seat Hunter (which would be familiar to those who had flown

Martel in service

The AJ.168 TV-guided Martel provided the Buccaneer with a dramatic increase in its precision attack capability compared to the little-used Bullpup. However, the advances made to close-in ship defences had rendered the TV version largely obsolete by the mid-1980s, chiefly on account of its medium-altitude approach and the fact that each aircraft could only launch one at a time. Conversely, the AR Martel remained in full usage until the retirement of the Buccaneer in 1994.

*Right: This No. 12 Squadron aircraft is in typical Martel fit, carrying a single **AR** missile on the port outer pylon, two **TV**-guided weapons and the **TV** datalink pod on the starboard inner. The datalink pod used an unusual rear-facing pylon.*

This pair of Buccaneers is led by a No. 12 Squadron aircraft carrying the AS.37 anti-radiation Martel. The characteristic strake down the side of the missile provided a conduit for the necessary wires to link the various sections of the weapon. The AR Martel had three interchangeable homing heads working in different frequency bands, chosen and fitted prior to take-off, depending on the expected nature of the target.

The OCU continued to provide replacement aircrew for No. 809 Squadron, and an 'RN Unit' was set up within the OCU to handle the Navy-specific training requirements. Deck landings were practised on a dummy carrier deck marked out on the Honington runway, and catapult launches (from dry land) were undertaken at RAE Bedford, while FAA crews were also required to become qualified in air-to-air refuelling. Aircrew destined for No. 809 Squadron thus flew a few extra sorties at the conclusion of their time on the OCU, although actual carrier qualification was undertaken on the squadron.

Graduates of No. 237 OCU's first Long Course thus became available for posting to front-line squadrons by late September 1971. By this time, both Nos 12 and 15 were well into their stride, although not completely without problems. No. 15 lost its CO, Wing Commander D. J. H. Collins, in the crash of XW532 at Venlo, Netherlands on 25 March 1971, this being the RAF's first Buccaneer loss. No. 12 Squadron also suffered two accidents in 1971 – XN978 near Creil on 5 June and XV347 in a ground engine fire at Lossiemouth on 9 December.

A third squadron

Ten new-build Buccaneer S.Mk 2Bs came off the Brough line in 1971 – a modest total when compared with the monthly total of 50 F-4 Phantom IIs which McDonnell at St Louis produced at the peak of the Vietnam War, but still a respectable rate by British standards – which allowed a third squadron to be formed in 1972. This was No. 16 Squadron, which joined No. 15 at Laarbruch in the RAF Germany nuclear QRA mission.

Counter-air missions against airfields and interdiction sorties against lines of communication and enemy ground forces were regularly practised in training, typically involving a number of aircraft attacking with 1,000-lb bombs. Rocket projectiles (2-in) were used by the RAF squadrons

the type with No. 4 FTS at Valley, or on No. 229 OCU at Chivenor), interspersed with simulator trips, before getting airborne for the first time in a Buccaneer with a flying instructor in the rear seat. The 20-week course took the student from conversion to type through night and formation flying, tactics and weapons delivery to the final sorties, which involved the planning and flying of simulated 'live' attack missions. Graduates were then posted to front-line squadrons, where they would spend the first few months working up to combat ready status. By the end of 1971, the OCU had received its full complement of aircraft, which were mainly S.Mk 2As but also included a few interim S.Mk 2Bs with Martel pylons.

Typical anti-ship operations in the Martel days might have seen six aircraft attacking one target, carrying a mix of **TV** Martels, **AR** weapons (seen here) and laser-guided bombs. The formation would have carried two **AR** Martels, to be launched from long range in an attempt to give the ship's radar defences a dilemma: if they switched on, the **AR** Martels would home on the radars, but if they stayed silent, the **TV** Martel/**LGB** aircraft could press their attacks in much greater safety.

Buccaneer S.Mk 2B
No. 208 Squadron
RAF Lossiemouth

Typical of the Buccaneer in its later RAF career, this No. 208 Squadron example has the bomb door tank modification, fin-top RWR and is painted in the full wrap-round camouflage. It is shown loaded with CBLS stores for the carriage of practice bombs.

Anti-radiation Martel
An important weapon for the anti-ship mission was the MATRA/BAe AS.37 AR Martel. This used the same body as the TV Martel but had a passive radar seeker and a blast fragmentation warhead instead of semi-armour piercing. It was slightly longer (13 ft 9 in/4.20 m) and heavier (1,180 lb/535 kg at launch), and had a much greater range (34 miles/55 km).

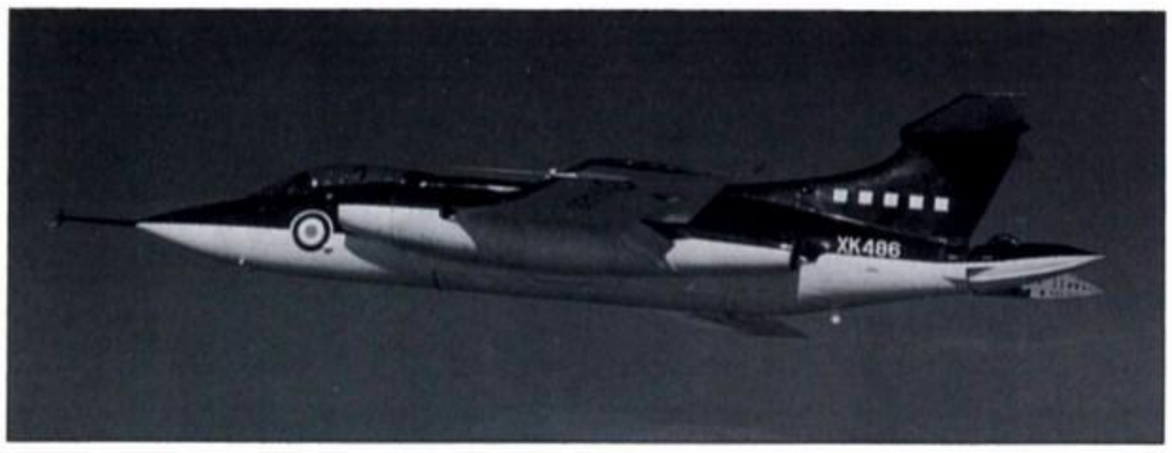
Slipper tanks
Aerodynamic considerations precluded the fitment of the large SAAF slipper tanks on RAF S.Mk 2Bs, so they retained the original 250-Imp gal (1136-litre) tanks developed for the Navy. The tanks were theoretically jettisonable, although in practice this capability would have been used only in an emergency or wartime.

WE177A
In the nuclear strike role the Buccaneer was armed with the WE177A tactical nuclear weapon. Developed to Air Staff Requirement 1177 of 1963, the WE177A (or '600-lb weapon') was originally intended for service with both the Buccaneer and the TSR.2, and was parachute-retarded for low-level laydown deliveries. It could also be tossed. Flight trials began in 1965, using Buccaneer XK528 among other test airframes. The 950-lb WE177B was developed as a strategic weapon for deployment on the Vulcan. Service clearance for the Buccaneer was conducted by No. 803 Squadron in 1969, although it is unclear whether the WE177A became a full part of the Royal Navy armoury. RAF aircraft initially carried one in an interim fit, but were soon provided with modified bomb doors with two WE177 stations (9 and 10). Dimensions of the WE177A were 12 ft (3.66 m) length, 16.5 in (42 cm) diameter and 24 in (61 cm) tailfin span.

Area weapons
Unguided rockets formed an important part of the Buccaneer's armoury in its early career for attacks against area targets. Initially the 36-round No. 7 Mk 1 launcher was used for 2-in RP (rocket projectiles), but later the TDA 68-mm SNEB, fired from a 18-round MATRA 155 pod, took over. The SNEB was relinquished by the RAF on adoption of the Hunting BL755 cluster bomb, which contained 147 GP (general purpose) or AAA (Advanced Anti-Armour) bomblets. The BL755 weighed 611 lb (277 kg) when loaded.

Keith Fretwell

Buccaneer colours



Prototypes and pre-production

The first prototype was initially painted in a unique scheme with dark blue upper surfaces and white undersides, in gloss paint (above). Five white squares were painted on the fin. Subsequent pre-production aircraft had a rough approximation of the first Royal Navy scheme, gloss extra dark sea grey replacing the dark blue on the upper surfaces. The fins, however, were left white in contrast to the operational scheme. Roundels were applied in varying sizes and positions, reportedly in an attempt to confuse unwanted onlookers who may have been trying to determine the aircraft's exact dimensions from the roundels. Some later pre-production aircraft appeared in anti-flash white. During the flight trials, some aircraft acquired additional markings for photo-calibration or conspicuity.

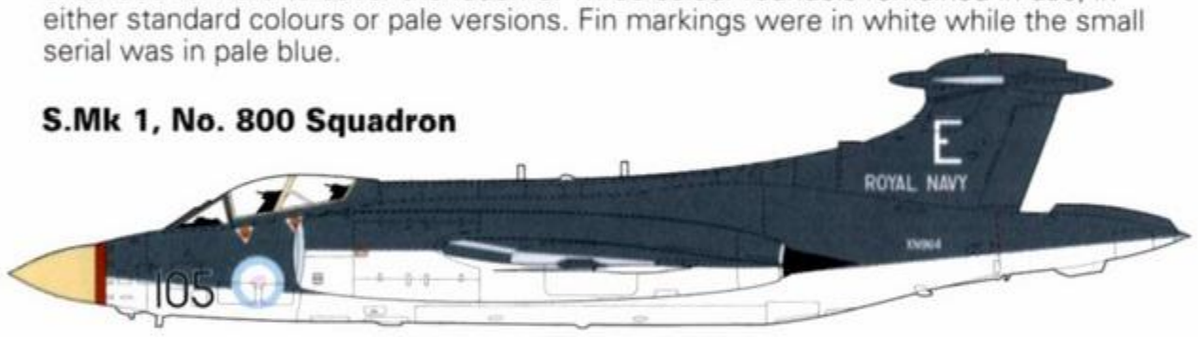
Royal Navy

Some early S.Mk 1s were painted in an overall anti-nuclear flash white scheme similar to that worn by the V-force. Pale pink and blue was used for the national insignia, with codes presented in pale blue. Only the 'Royal Navy' marking was in black. The radome was left unpainted. These aircraft were jokingly referred to as 'peeled bananas' and served only briefly in this scheme with 801 and 809 Squadrons.

S.Mk 1, No. 801 Squadron

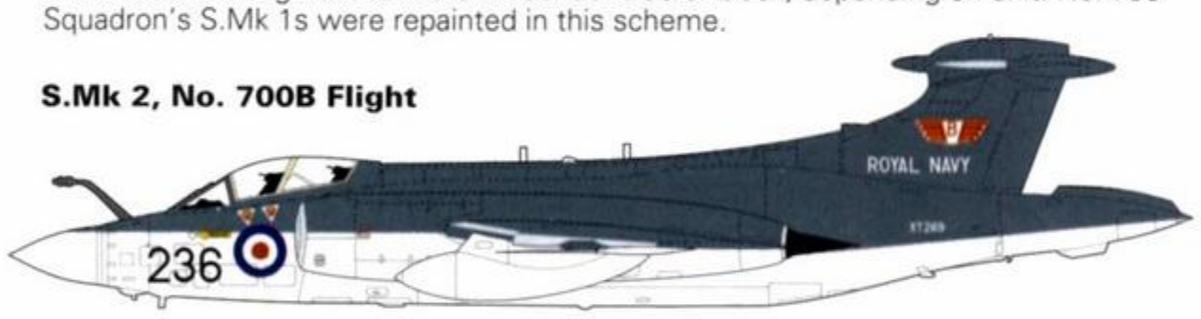
The standard Royal Navy scheme consisted of gloss extra dark sea grey upper surfaces, extending up the fin, with gloss white undersides. The scheme was extended forward to cover the radome. Three-colour roundels remained in use, in either standard colours or pale versions. Fin markings were in white while the small serial was in pale blue.

S.Mk 1, No. 800 Squadron

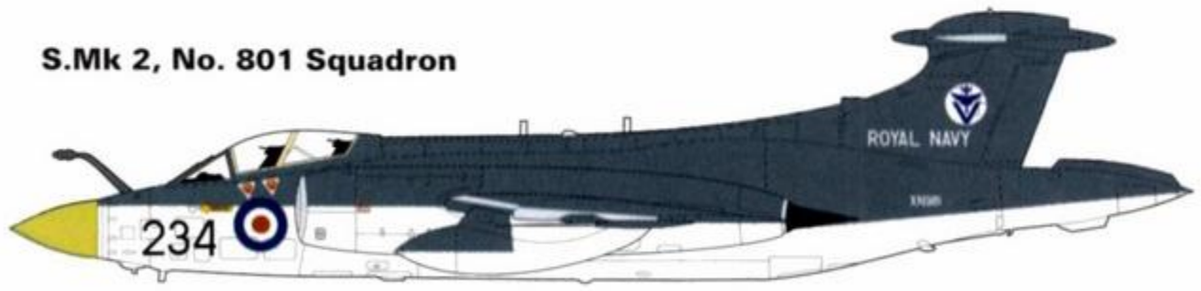


The S.Mk 2 introduced a modified colour scheme, still using gloss extra dark sea grey/white but with a revised demarcation line. Fin markings and serials were in white, with full-colour roundels. The serial was repeated under the wings in roundel blue, while the three-digit codes were in roundel blue or black, depending on unit. No. 736 Squadron's S.Mk 1s were repainted in this scheme.

S.Mk 2, No. 700B Flight

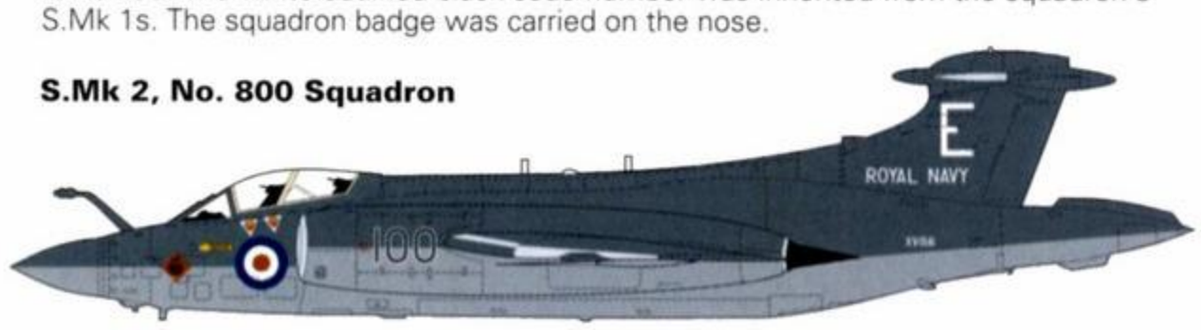


S.Mk 2, No. 801 Squadron



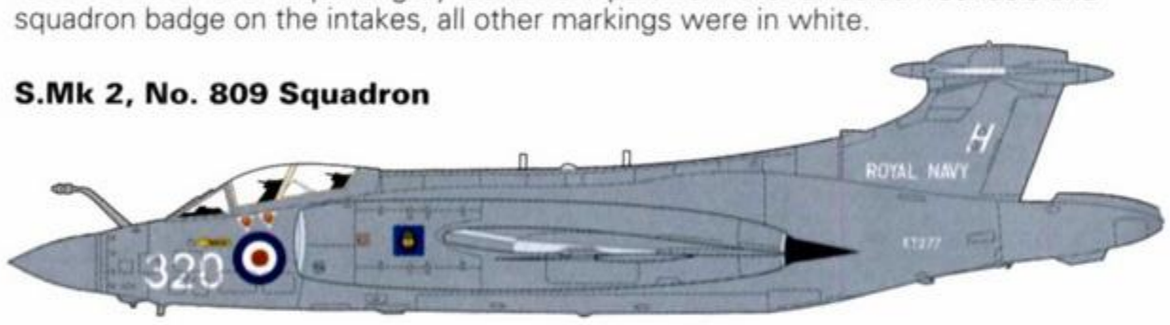
In the search for new Buccaneer colour schemes, this aircraft of No. 800 Squadron had its undersides repainted in 'squirrel grey'. The extra dark sea grey upper surfaces remained. The white-outlined black code number was inherited from the squadron's S.Mk 1s. The squadron badge was carried on the nose.

S.Mk 2, No. 800 Squadron



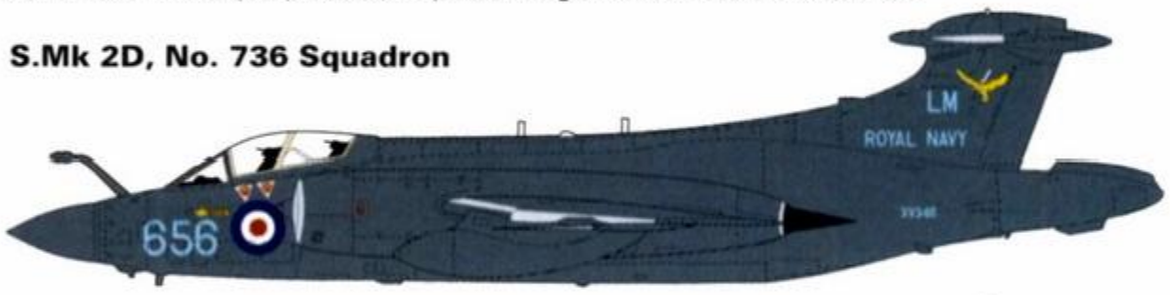
Another camouflage experiment involved this No. 809 Squadron aircraft, which received an all-over 'squirrel grey' scheme. Apart from the full-colour roundels and squadron badge on the intakes, all other markings were in white.

S.Mk 2, No. 809 Squadron

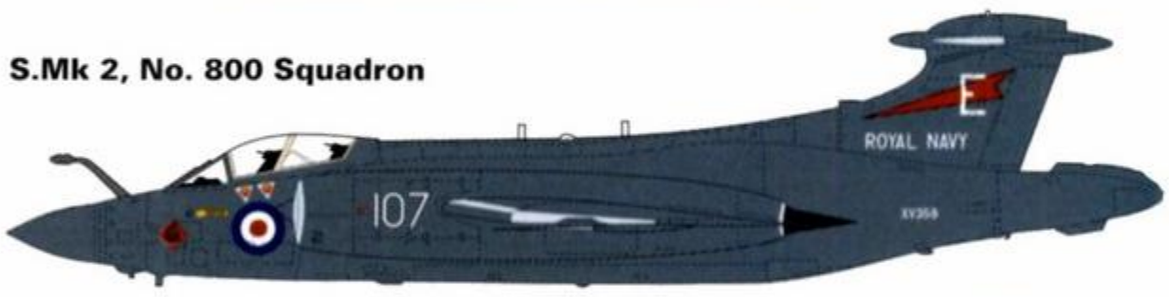


Shortly after the S.Mk 2 entered service the basic scheme was changed to an all-over gloss extra dark sea grey, with full-colour roundels. Pale blue was used for most markings, although deck letters were usually white. No. 800 used white codes and continued its unique practice of presenting them on the intake sides.

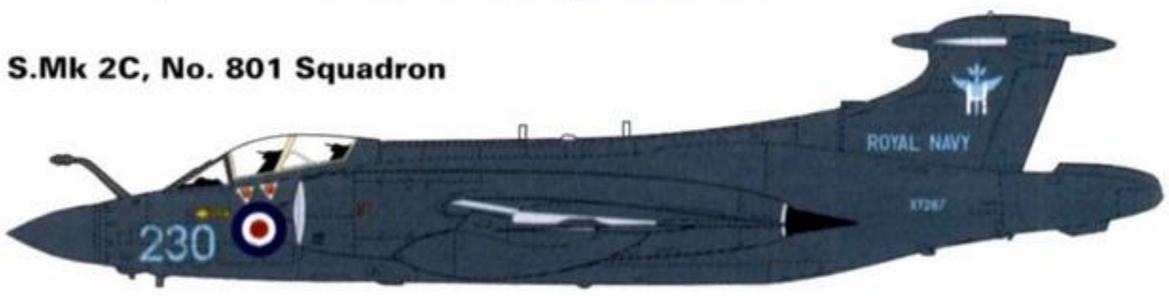
S.Mk 2D, No. 736 Squadron



S.Mk 2, No. 800 Squadron

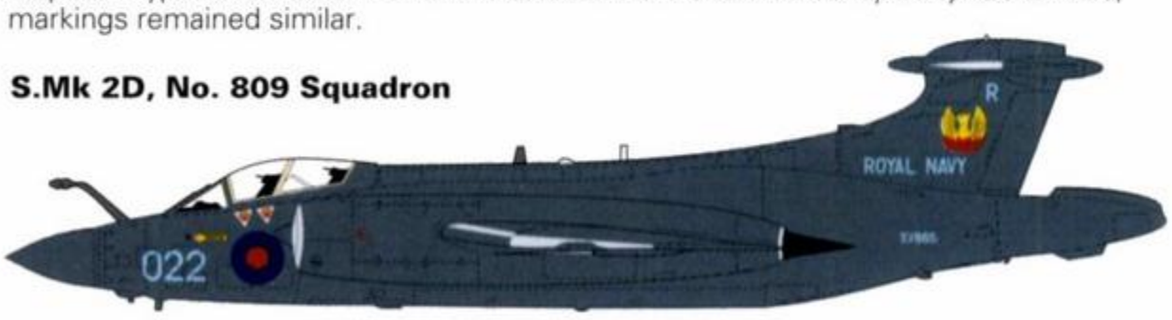


S.Mk 2C, No. 801 Squadron



From about 1972 the surviving Royal Navy Buccaneers serving with No. 809 Squadron acquired Type B roundels in an effort to reduce the aircraft's conspicuity. Otherwise, markings remained similar.

S.Mk 2D, No. 809 Squadron

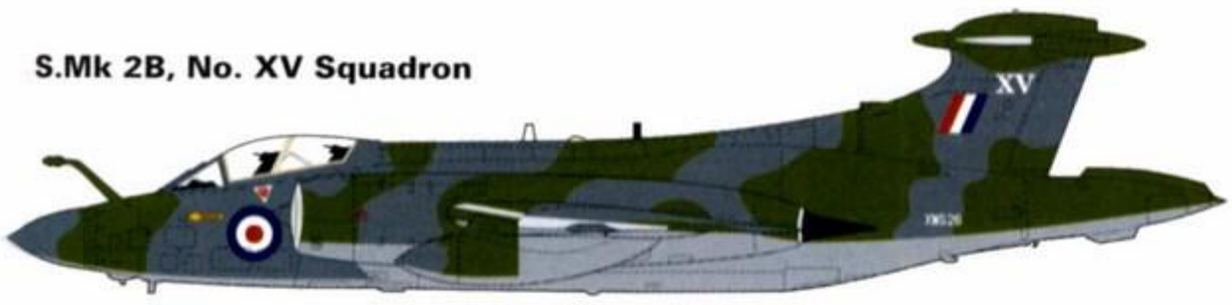


The extra dark sea grey finish was perfectly suited to overwater operations, especially in the North Atlantic. This is a No. 809 Squadron aircraft.

Royal Air Force

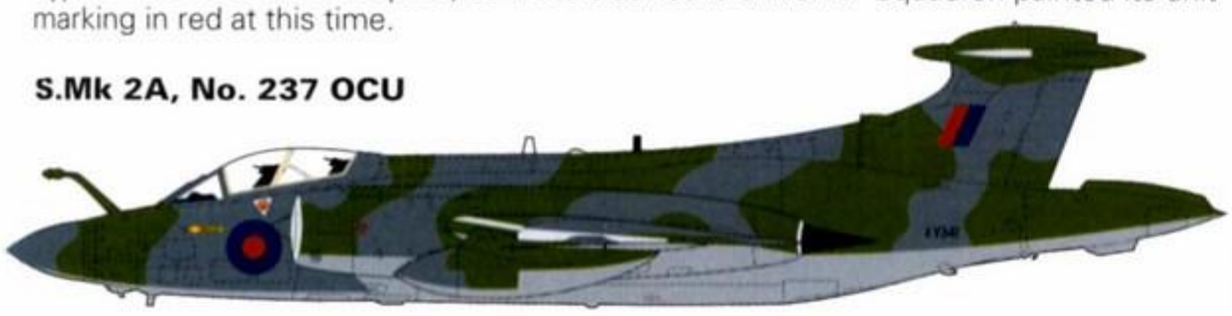
The first aircraft delivered to the RAF wore the standard tactical camouflage of the day: gloss dark green and dark sea grey in a disruptive pattern on the upper surfaces, with light aircraft grey underneath. Fuselage serials were in white, with underwing serials in black.

S.Mk 2B, No. XV Squadron



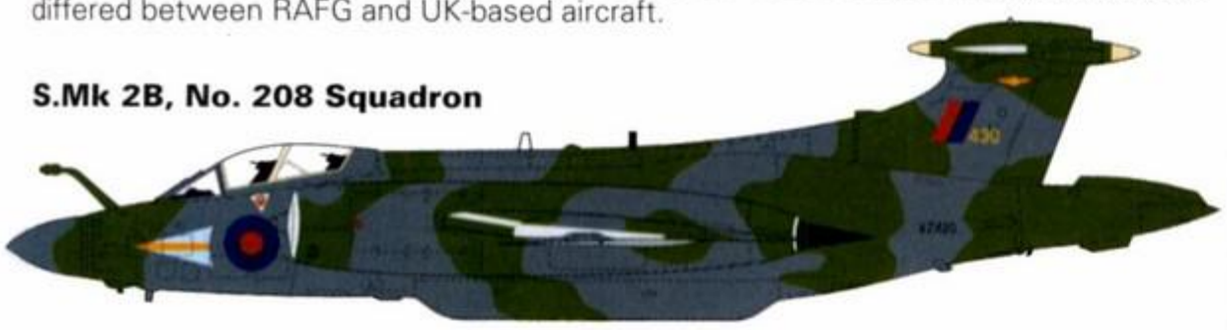
In 1972 a lower conspicuity scheme was adopted, using matt paint instead of gloss. Type B roundels were adopted, as were black serials. No. XV Squadron painted its unit marking in red at this time.

S.Mk 2A, No. 237 OCU



Following Red Flag experience the matt dark green/dark sea grey scheme was wrapped round the entire aircraft, as the previous light undersides often caused the aircraft to stand out while manoeuvring at low level. The underside disruptive patterns differed between RAFG and UK-based aircraft.

S.Mk 2B, No. 208 Squadron

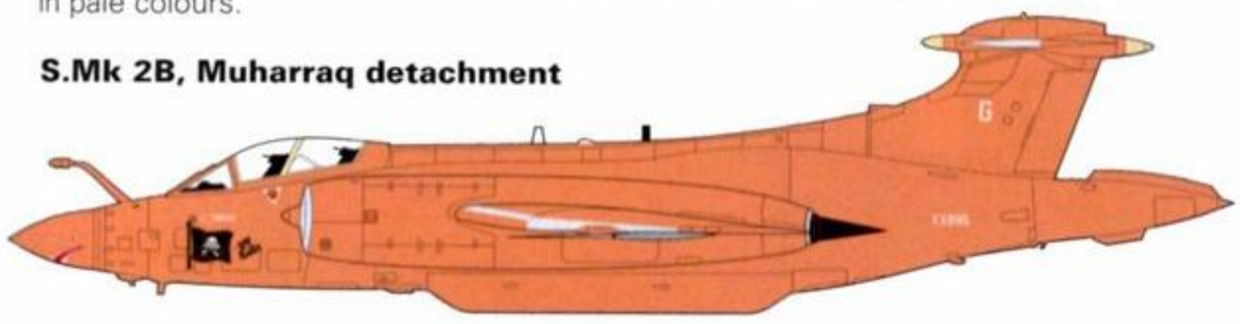


In keeping with its AFNORTH mission, in 1977 No. 208 Squadron applied a temporary white distemper over the dark sea grey portion of the standard camouflage.

For participation in the 1977 Red Flag series, No. 208 used an experimental matt dark earth/light stone desert scheme applied over most of the base camouflage.

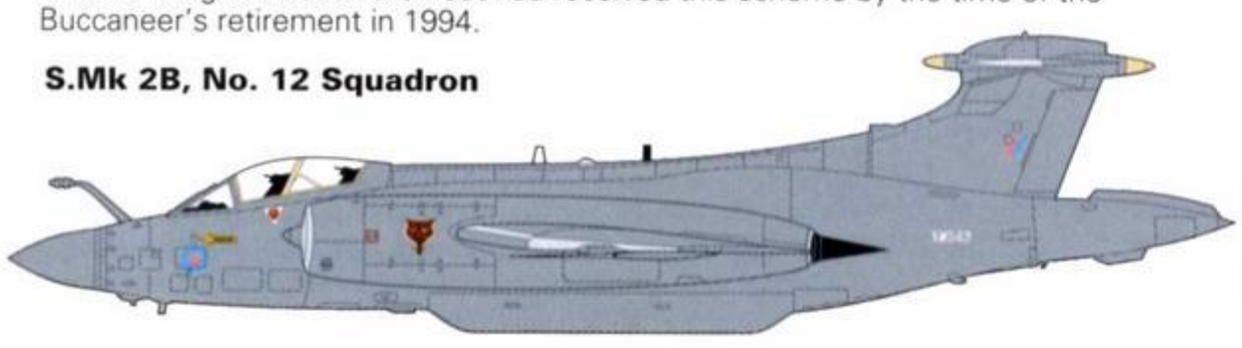
Thirteen of the 14 aircraft prepared for Operation Granby also received sand-coloured ARTF (Alkali Removable Temporary Finish) paint over the top of the standard camouflage. ECM and Pave Spike pods also received ARTF. Single-letter codes and serial numbers were applied in white. National insignia were applied to the wings only, in pale colours.

S.Mk 2B, Muharraq detachment



Following the Buccaneer's return from the Gulf, a new scheme was adopted for the aircraft consisting of an all-over medium sea grey with serials in white and small, pale national insignia. Not all the fleet had received this scheme by the time of the Buccaneer's retirement in 1994.

S.Mk 2B, No. 12 Squadron

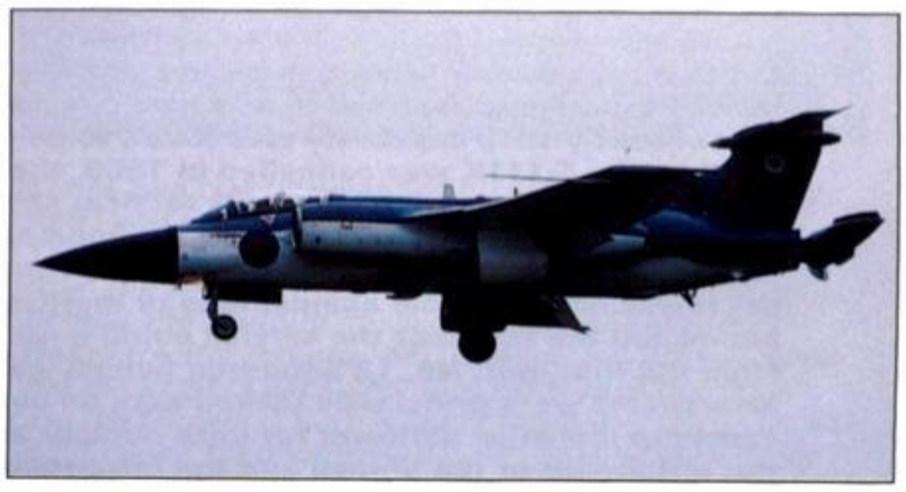


Ministry of Defence (Procurement Executive)

The three aircraft procured specifically for the RAE had an unusual yellow, white and dark green (almost black) scheme, with the serial applied in large black letters across the bomb bay. This scheme was adopted for photo-calibration purposes. Two of the aircraft subsequently acquired the red/white/blue 'raspberry ripple' scheme.

S.Mk 2B, Royal Aircraft Establishment

The single S.Mk 2B procured for the Radar Research Establishment was delivered in a mock Royal Navy scheme, with extra dark sea grey top sides and white undersides. The roundels were Type B, while the Foxhunter radome was black.

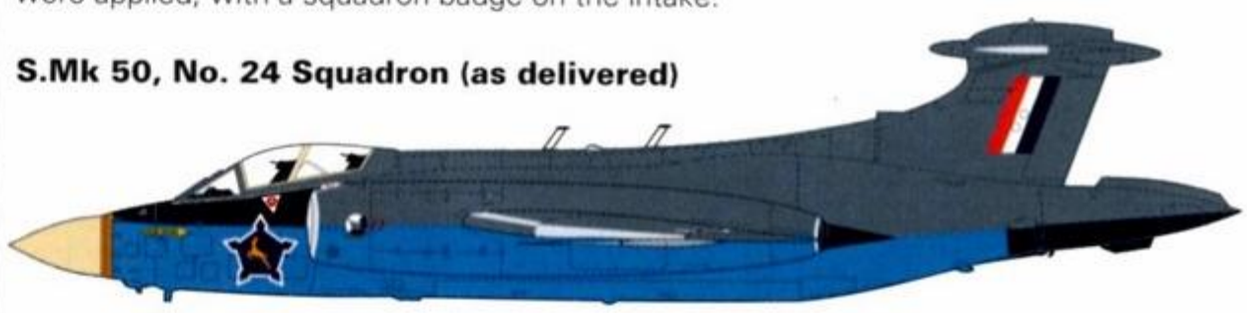


XW987 is shown after repaint in a variation of the MoD(PE) 'raspberry ripple' scheme. Replacement panels on the fin were left in standard RAF grey/green. Note the open bomb bay.

South African Air Force

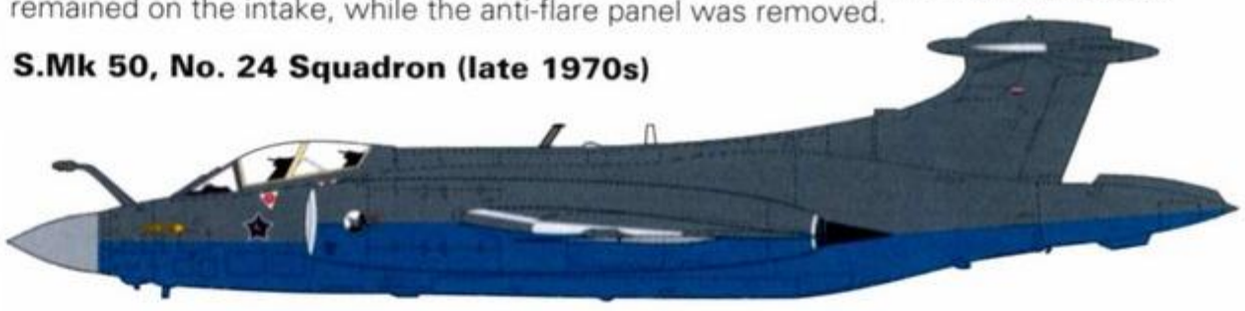
South Africa's S.Mk 50s were initially delivered in a two-tone finish with gloss dark sea grey upper surfaces and PRU blue lower sides. A matt black anti-glare panel was painted around the cockpit, while another matt black panel was added on the lower side of the tailcone. Paint was later extended over the radome. Large national insignia were applied, with a squadron badge on the intake.

S.Mk 50, No. 24 Squadron (as delivered)



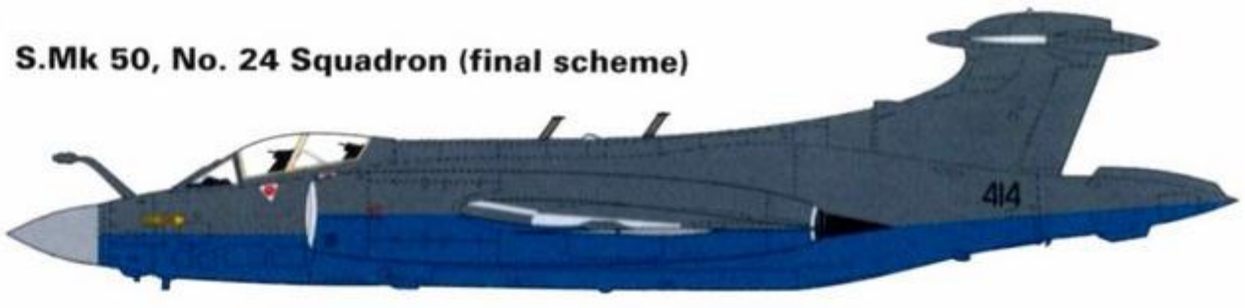
Spurred by the start of Buccaneer operations in Angola, the SAAF introduced a new reduced-conspicuity scheme in the late 1970s. This consisted of matt dark sea grey upper surfaces and matt slate blue lower surfaces. The national insignia were reduced in size, while the once huge fin-flash was reduced to a tiny flag. The squadron badge remained on the intake, while the anti-flare panel was removed.

S.Mk 50, No. 24 Squadron (late 1970s)



In the final years of SAAF Buccaneer operations all markings were removed with the exception of the three-digit aircraft serial, worn in black on the rear fuselage. In earlier paint schemes this had also been worn in large digits under the wings.

S.Mk 50, No. 24 Squadron (final scheme)



Gulf War nose art

The 12 Buccaneers deployed to Muharraq acquired nose artwork to some degree. All were named after local malt whiskies, and all but one featured a 'Sky Pirates' skull-and-crossbones on the port side of the nose. Each 'Sky Pirates' badge was individually decorated, such as this eye-patch-wearing example (right) on XV352. Variations included skulls wearing headphones, a headband or make-up. Seven of the aircraft received more typical nose art, as did one of the two prepared aircraft which did not deploy. Furthermore, XX895 had a red/white shark-mouth applied.

XW533/A **Glenfarclas/Fiona/Miss Jolly Roger**

XW530/E **Glenmorangie**

XX895/G **Glenfiddich/Lynn/Jaws**

XX892/I **Glen Lossie**

XX885/L **Famous Grouse/Caroline/Hello Sailor**

XX901/N **Glen Elgin/Flying Mermaid/Kathryn**

XX894/O **Aberlour**

XX899/P **Linkwood/Laser Lips Laura**
This aircraft had its artwork on the port side instead of the starboard side to indicate that the artwork's origins lay with the aircrew, rather than the ground crew.

XW547/R **The Macallan/Pauline/Guinness Girl**

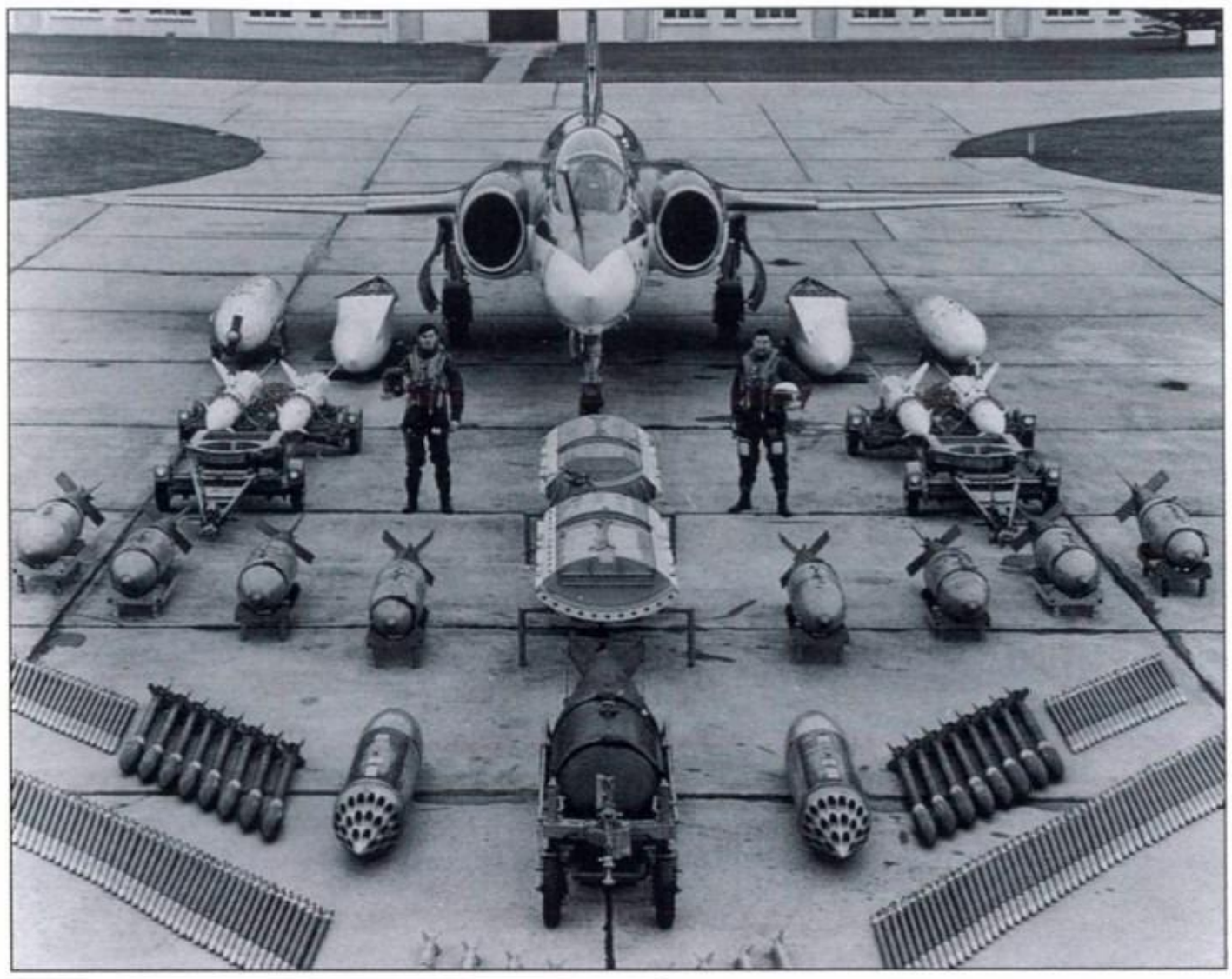
XV863/S **Tamnavoulin/Debbie/Sea Witch**

XX889/T **Longmorn**

XV352/U **Tamdhu**

XV332/uncoded **Dirty Harriet**
One of two aircraft to be prepared for Gulf service but not deployed.

Buccaneer weapons



These two classic weapons displays show the early (left) and final (above) weapons of the Buccaneer. The 1960s S.Mk 2 could carry a variety of weapons, from the 2-in RP (foreground), through 1,000-lb bombs and Bullpup missiles, to the 2,000-lb Red Beard (centre foreground). Behind the nuclear bomb are the camera pack and flare pack. Also noticeable are the Gloworm flare rockets (outboard of the rocket pods) used for nocturnal illumination of targets. By contrast, the 1990s Buccaneer had a variety of precision weapons at its disposal (AR Martel, Paveway II laser-guided bombs and Sea Eagle).

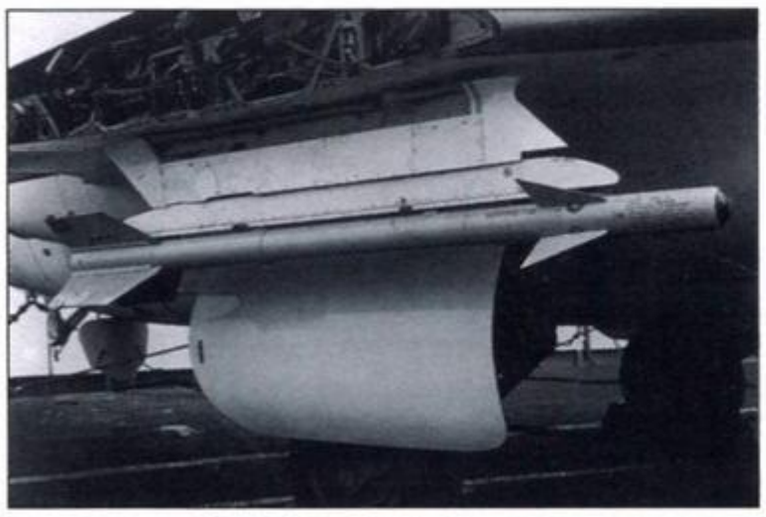
AGM-12 Bullpup (left) – This radio command-guided missile was used sporadically by the Navy. Up to four could be carried, providing the Buccaneer with some short-range precision attack capability.

Martel (above) – Used in the anti-ship role, the Martel was available with either a TV seeker and radio command guidance (AJ.168 – inboard) or a passive radar homing seeker (AS.37 – outboard). Both required special launch rails, the TV version having an extended rail with an umbilical to connect the seeker head to the aircraft's cockpit display.

Rockets (right) – Two types of rocket were used, the 2-in RP (illustrated) in a 36-round pod and the 68-mm SNEB fired from a 24-round pod. SNEBs were retired in favour of BL755 cluster bombs

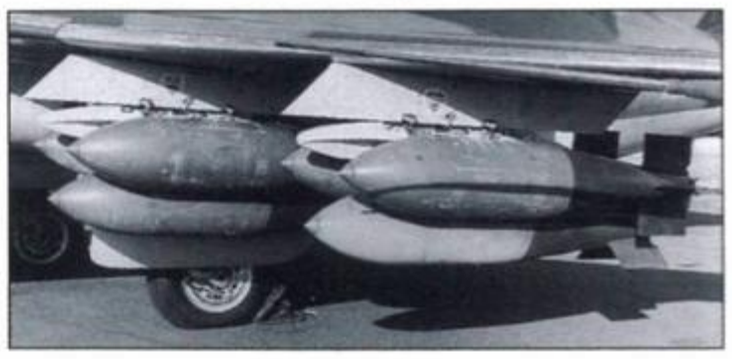
Sea Eagle (below) – Offering excellent range, fire-and-forget capability and sea-skimming approach, the Sea Eagle was a potent ship-killer.

WE177 (above) – The WE177 nuclear bomb was used on the Buccaneer in its 600-lb (272-kg) WE177A tactical version. This was believed to have had several yield options.



AIM-9 Sidewinder – Royal Navy Buccaneers used the AIM-9B version of the weapon (left), which were transferred with the aircraft to the RAF. In the early 1980s the RAF cleared the aircraft to use the AIM-9G (below) and all-aspect AIM-9L (above).

Bombs – The standard weapon was the 1,000-lb (454-kg) bomb, seen below on a test triple ejector rack. Various other weapons such as the 500-lb (227-kg) and 540-lb (245-kg) bombs were also used, as was the BL755 cluster bomb. A commonly seen store was the CBLS (Carrier Bomb Light Store – above), which housed practice bombs. The CBLS could also be carried internally, with 28-lb (12.7-kg) practice bombs, to mimic the delivery procedure and ballistics of nuclear weapons.



Blackburn (HS) Buccaneer S.Mk 2B
No. 12 Squadron
RAF Lossiemouth

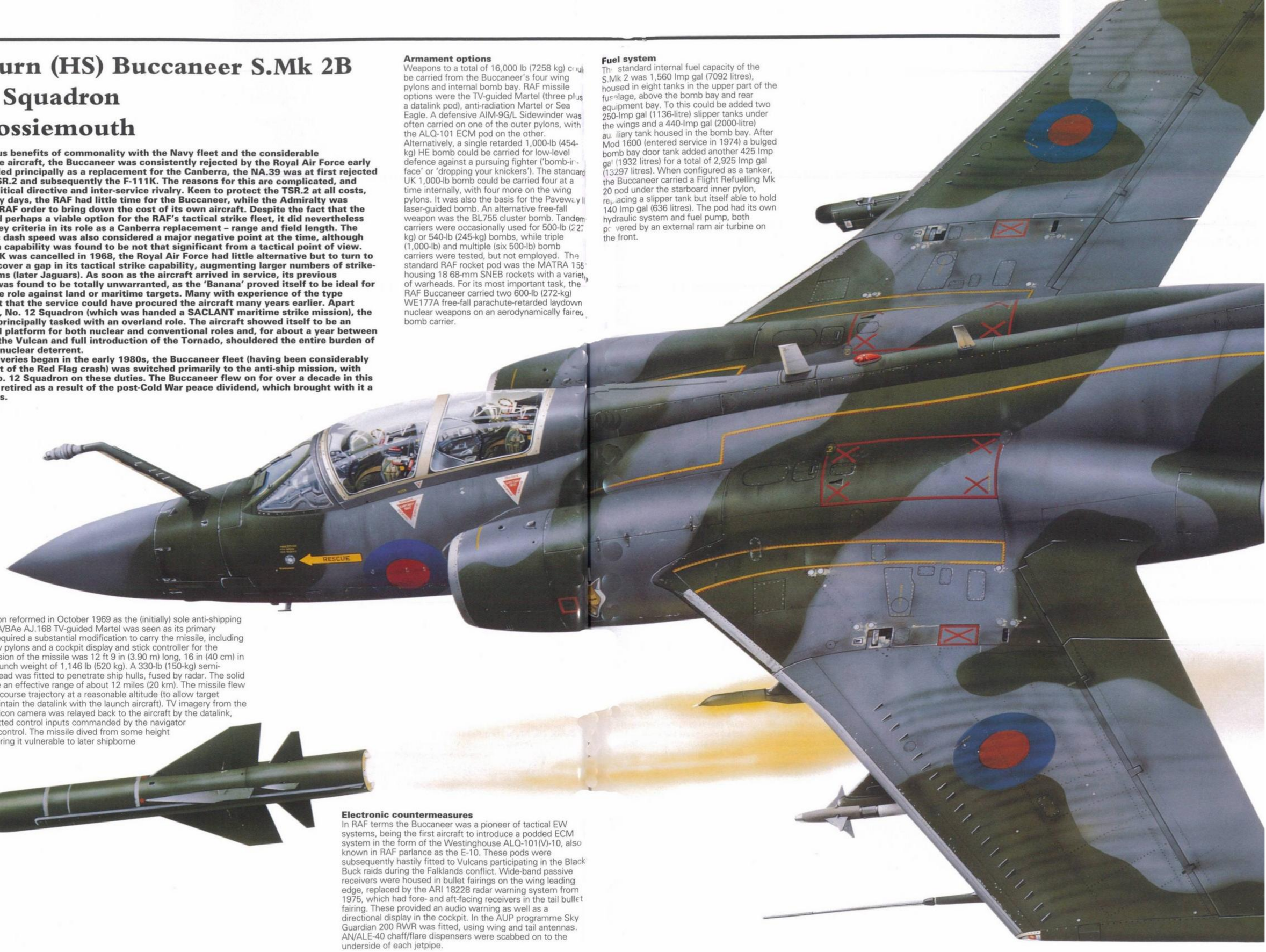
Despite the obvious benefits of commonality with the Navy fleet and the considerable performance of the aircraft, the Buccaneer was consistently rejected by the Royal Air Force early in its career. Studied principally as a replacement for the Canberra, the NA.39 was at first rejected in favour of the TSR.2 and subsequently the F-111K. The reasons for this are complicated, and involved much political directive and inter-service rivalry. Keen to protect the TSR.2 at all costs, at least in the early days, the RAF had little time for the Buccaneer, while the Admiralty was anxious to see an RAF order to bring down the cost of its own aircraft. Despite the fact that the NA.39 represented perhaps a viable option for the RAF's tactical strike fleet, it did nevertheless fail to meet two key criteria in its role as a Canberra replacement – range and field length. The lack of supersonic dash speed was also considered a major negative point at the time, although subsequently such capability was found to be not that significant from a tactical point of view.

When the F-111K was cancelled in 1968, the Royal Air Force had little alternative but to turn to the Buccaneer to cover a gap in its tactical strike capability, augmenting larger numbers of strike-dedicated Phantoms (later Jaguars). As soon as the aircraft arrived in service, its previous 'unwanted' label was found to be totally unwarranted, as the 'Banana' proved itself to be ideal for the low-level strike role against land or maritime targets. Many with experience of the type bemoaned the fact that the service could have procured the aircraft many years earlier. Apart from the first unit, No. 12 Squadron (which was handed a SACLANT maritime strike mission), the Buccaneers were principally tasked with an overland role. The aircraft showed itself to be an excellent low-level platform for both nuclear and conventional roles and, for about a year between the retirement of the Vulcan and full introduction of the Tornado, shouldered the entire burden of the UK's airborne nuclear deterrent.

As Tornado deliveries began in the early 1980s, the Buccaneer fleet (having been considerably reduced as a result of the Red Flag crash) was switched primarily to the anti-ship mission, with No. 208 joining No. 12 Squadron on these duties. The Buccaneer flew on for over a decade in this role, before being retired as a result of the post-Cold War peace dividend, which brought with it a surfeit of Tornados.

Armament options
Weapons to a total of 16,000 lb (7258 kg) could be carried from the Buccaneer's four wing pylons and internal bomb bay. RAF missile options were the TV-guided Martel (three plus a datalink pod), anti-radiation Martel or Sea Eagle. A defensive AIM-9G/L Sidewinder was often carried on one of the outer pylons, with the ALQ-101 ECM pod on the other. Alternatively, a single retarded 1,000-lb (454-kg) HE bomb could be carried for low-level defence against a pursuing fighter ('bomb-in-face' or 'dropping your knickers'). The standard UK 1,000-lb bomb could be carried four at a time internally, with four more on the wing pylons. It was also the basis for the Paveway II laser-guided bomb. An alternative free-fall weapon was the BL755 cluster bomb. Tandem carriers were occasionally used for 500-lb (227-kg) or 540-lb (245-kg) bombs, while triple (1,000-lb) and multiple (six 500-lb) bomb carriers were tested, but not employed. The standard RAF rocket pod was the MATRA 155 housing 18 68-mm SNEB rockets with a variety of warheads. For its most important task, the RAF Buccaneer carried two 600-lb (272-kg) WE177A free-fall parachute-retarded laydown nuclear weapons on an aerodynamically faired bomb carrier.

Fuel system
The standard internal fuel capacity of the S.Mk 2 was 1,560 Imp gal (7092 litres), housed in eight tanks in the upper part of the fuselage, above the bomb bay and rear equipment bay. To this could be added two 250-Imp gal (1136-litre) slipper tanks under the wings and a 440-Imp gal (2000-litre) auxiliary tank housed in the bomb bay. After Mod 1600 (entered service in 1974) a bulged bomb bay door tank added another 425 Imp gal (1932 litres) for a total of 2,925 Imp gal (13297 litres). When configured as a tanker, the Buccaneer carried a Flight Refuelling Mk 20 pod under the starboard inner pylon, replacing a slipper tank but itself able to hold 140 Imp gal (636 litres). The pod had its own hydraulic system and fuel pump, both powered by an external ram air turbine on the front.



TV Martel missile
When No. 12 Squadron reformed in October 1969 as the (initially) sole anti-shipping squadron, the MATRA/BAe AJ.168 TV-guided Martel was seen as its primary equipment. Aircraft required a substantial modification to carry the missile, including the installation of new pylons and a cockpit display and stick controller for the navigator. The TV version of the missile was 12 ft 9 in (3.90 m) long, 16 in (40 cm) in diameter and had a launch weight of 1,146 lb (520 kg). A 330-lb (150-kg) semi-armour piercing warhead was fitted to penetrate ship hulls, fused by radar. The solid propellant motor gave an effective range of about 12 miles (20 km). The missile flew a predetermined mid-course trajectory at a reasonable altitude (to allow target acquisition and to maintain the datalink with the launch aircraft). TV imagery from the missile's Marconi Vidicon camera was relayed back to the aircraft by the datalink, which in turn transmitted control inputs commanded by the navigator using the small stick control. The missile dived from some height on to its target, rendering it vulnerable to later shipborne defence systems.

Electronic countermeasures
In RAF terms the Buccaneer was a pioneer of tactical EW systems, being the first aircraft to introduce a podded ECM system in the form of the Westinghouse ALQ-101(V)-10, also known in RAF parlance as the E-10. These pods were subsequently hastily fitted to Vulcans participating in the Black Buck raids during the Falklands conflict. Wide-band passive receivers were housed in bullet fairings on the wing leading edge, replaced by the ARI 18228 radar warning system from 1975, which had fore- and aft-facing receivers in the tail bullet fairing. These provided an audio warning as well as a directional display in the cockpit. In the AUP programme Sky Guardian 200 RWR was fitted, using wing and tail antennas. AN/ALE-40 chaff/flare dispensers were scabbed on to the underside of each jetpipe.

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Tailplane
Mounted atop the multi-spar fin, the tailplane and its bullet fairing were attached directly to the fin structure, the whole assembly moving to provide pitch control. The BLC system adopted for the wing incurred a massive pitch-down moment which the tailplane by itself could not counteract. To vastly increase the 'lift' (or downforce – in a high-lift configuration the tailplane works in an opposite sense to the wing, that is, producing lift, but lift which operates in a downwards direction) created by the tailplane, a sizeable flap was added, connected to the flap/aileron droop system so it that was automatically raised through 25° when the flaps/ailerons were lowered. Even this was not enough, so the bleed air blowing system was extended to the tailplane, which featured full-span slits underneath the leading edge to prevent airflow separation from the underside of the tailplane and so prevent a tailplane stall at low speeds.

Rolls-Royce Spey engine
Power for the Buccaneer S.Mk 2 came from the Rolls-Royce RB.168-1A Spey Mk 101 non-afterburning turbofan, developing 11,030 lb (49.08 kN) thrust, or around 9,500 lb (42.27 kN) with the full blowing system working. Unlike the Gyron Junior, the operating temperatures could not be temporarily increased to recover this lost thrust.The powerplant was developed from the RB.163 engine originally designed for the Trident airliner, offering far more power than the Gyron Junior and with far better specific fuel consumption. The military-spec engine was essentially similar to that of the Trident apart from modifications necessary for operations in the high-speed, low-level regime. The engine fitted into the airframe relatively easily, but required a much larger intake to handle the 80 per cent greater mass flow, and needed a revised air bleed system to cope with the much higher pressure generated by the engine. The engines were toed out to alleviate asymmetric handling problems in the event of a single engine failure.

The Spey Mk 101 was a two-spool engine, each spool operating independently of the other. The internal shaft was the low-pressure unit, with a four-stage (five in later engine variants) compressor driven by a two-stage trubine. Rotating around the LP shaft was the high-pressure spool, again driven by a two-stage turbine but mounting a 12-stage compressor. Bypass ratio was typically 0.71. Attached to each engine were two gearboxes, each with two pumps attached to pressurise the hydraulic system. In addition to the main wing blowing system, further air was bled off through a common duct for tailplane blowing, cabin and equipment bay heating, windscreen clearance, and for various fuel system/purging functions. The latter required that the hot air be passed through a heat exchanger.

Structure and wings
The heart of the Buccaneer's construction lay in two immensely strong structures which ran across the aircraft's centre section. Each comprised two ring mounts for the engines, joined by an arched structure to carry loads across the bomb bay. On the outer sides of the engine support rings were attached the two steel main wing spars, which terminated at the wing-fold line. The inboard (fixed) wing section also had an auxiliary aluminium spar attached to further engine rings. The main fuselage was built in three sections, the fore and aft sections attaching to the centre section, with nose and tailcones added to these.

The outer wings had two aluminium spars, and were folded by the aircraft's primary hydraulic system, which operated at 4,000 lb/sq in and drove all of the aircraft's systems apart from the flying controls, which were driven by a secondary 3,300 lb/sq in system. The wing itself had compound sweep, equating to quarter-chord values of 40° at the root, then 38° 36' and finally 30° 12' for much of the outer panel. It was set at 2° 30' incidence and had an aspect ratio of 3.55.

Wing surfaces and BLC/anti-icing system
The key to operating the heavyweight Buccaneer from the short-deck carriers of the Royal Navy lay in the boundary layer control system (dubbed 'supercirculation system'), which utilised high-pressure air drawn from the engines' high-pressure compressors (at the seventh stage), and blew it across the flaps and ailerons. By blowing air over the upper surfaces of the depressed wing surfaces, the boundary layer remained attached at lower speeds than was possible without blowing. In the initial B.103 design, the flaps were of greater span, split into two sections either side of the wing-fold line. The decision was then taken to also droop the ailerons by 25° for take-off/landing, and provide these with blowing, too. With drooped, blown ailerons the flaps could be restricted to simple sections on the fixed part of the wing only, drooping 45° for landing. The outer wing panels also had a row of vortex generator vanes aft of the leading edge to further excite the boundary layer air.

In the initial B.103 design leading-edge slats were fitted to further increase lift at high angles of attack. However, they precluded the use of hot engine bleed air to be used for anti-icing of the leading edge. Studies of alternative electrical systems showed them to be too much of a drain on the aircraft's power system. To solve these problems, Blackburn dispensed with the leading-edge slats, replacing them with slits (of between 0.025 and 0.046-in/ 0.6 to 1.2-mm width) through which hot supersonic bleed air was blown. This not only served the purpose of deicing the leading edge, but also served the same purpose as the slats, that is, re-energising the boundary layer over the top of the wing. This elegant solution was not without complications: for instance, a valve shut-off system was required to provide air only to the leading edge when just anti-icing was required, i.e., in normal flight, while opening up the full wing system for landing and take-off, when blowing was required from the leading edge and over both ailerons and flaps. Another complication concerned the relative pressures while operating in the two regimes. On approach, the engines were producing only partial power, with a consequent reduction in bleed air pressure while the blowing outlets were fully open. However, at normal speed the engines were producing far more power, and bleed air was at a much higher pressure with only the narrow leading-edge slits as outlets. A regulation system was installed to avoid damaging the ducts when only anti-icing was employed.

Buccaneer details

One of the Buccaneer's most notable features was the split airbrake. Actuation was hydraulic, a central jack pushing out against a crosshead while drag links either side restrained the petals, causing them to open.

Above: This Buccaneer S.Mk 1 was lucky to survive a major birdstrike, the results of which are seen in the intake.

Right: Blackburn engineers lend scale to the Gyron Junior engine, seen in front of the prototype. The much more powerful Spey was of generally similar dimensions.

Buccaneer S.Mk 2B cutaway drawing

1 Inflight-refuelling probe
2 Radar scanner
3 Multi-mode search and fire control radar
4 Weapon recorder
5 Radome (folded)
6 Radome hinge
7 Weapon release computer
8 Windscreen rain dispersal duct
9 Windscreen wiper
10 Birdproof windscreen
11 Pilot's head-up display
12 Instrument panel shroud
13 Rudder pedals
14 Nosewheel leg hinge point
15 Landing and taxi lamp
16 Shock absorber strut
17 Nosewheel forks
18 Aft-retracting nosewheel
19 Avionics equipment
20 Engine throttles
21 Canopy side rail
22 Pilot's ejection seat
23 Seat firing handle
24 Aft-sliding canopy
25 Navigator's blast shield
26 Navigator's instrument display
27 Starboard engine air intake
28 Navigator's ejection seat
29 Cockpit floor structure
30 Head-up display symbol generator
31 Port engine air intake
32 Anti-icing air line
33 Air intake duct
34 Cockpit aft pressure bulkhead
35 Forward main fuselage fuel tank
36 Canopy motor
37 Canopy top rail
38 Rolls-Royce RB.168-1A Spey Mk 101 turbofan
39 Bleed air ducting
40 Detachable bottom cowling
41 Engine front mounting
42 Firewall frame
43 Engine aft mounting
44 Forward fuselage structure
45 Bleed air cross-over duct
46 Canopy hand winding shuttle
47 Detachable engine top cowling
48 Starboard slipper tank
49 Datalink acquisition pod
50 Datalink inboard pylon
51 Martel air-to-surface missile
52 Wing-fold hinge line
53 Leading-edge blowing air duct
54 UHF antenna
55 Dorsal spine structure
56 Anti-collision light
57 Wing fold actuator
58 Wing fold operating link
59 Starboard outer pylon
60 ARI 18218 aerial housing
61 Blown leading edge
62 Starboard navigation light
63 Formation light
64 Starboard blown aileron
65 Aileron actuator
66 Starboard wingtip (folded)
67 Aileron and flap blowing ducts
68 Starboard blown flap
69 Port wingtip (folded)
70 Centre fuselage fuel tank
71 Machined spar ring frames
72 Ring frame bolted attachment
73 Aft fuselage fuel tank
74 Electrical cable ducting in dorsal spine
75 Avionics equipment bay
76 Air data computer
77 HF notch aerial
78 Equipment bay cooling air intake
79 Fin spar attachment
80 Fin structure
81 Tailplane actuator
82 Tailplane operating rod
83 Tailplane blowing air duct
84 Bullet fairing
85 Forward passive warning system antenna
86 Blown tailplane leading edge
87 All-moving tailplane structure
88 Tailplane flap
89 Tailplane flap actuator
90 Hinge attachment point
91 Top fairing
92 Rear navigation light
93 Formation light
94 Aft passive warning system antenna
95 Port tailplane flap
96 Rudder structure
97 Rudder operating link
98 Rudder actuator
99 Airbrake jack
100 Drag-link hinge attachment
101 Airbrake operating slide
102 Split tailcone airbrake
103 Top strake
104 Honeycomb reinforcing panel
105 Bottom strake
106 Airbrake (open)
107 Hinge arm
108 Aft fuselage structure
109 Vent pipe
110 Arrester hook
111 Jet efflux fairing
112 Engine jet pipe
113 Bomb bay door actuator
114 Bomb door aft hinge
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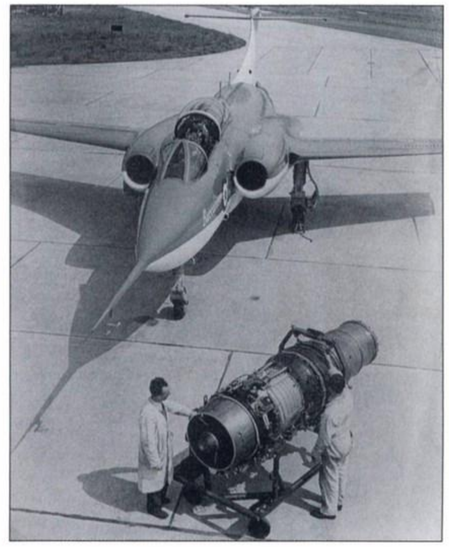

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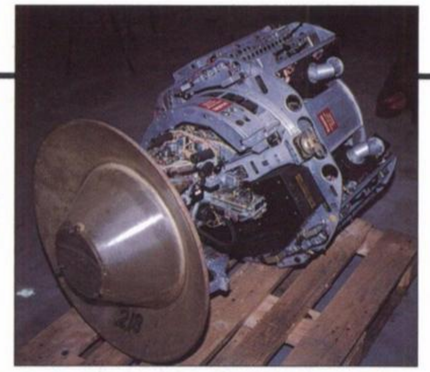
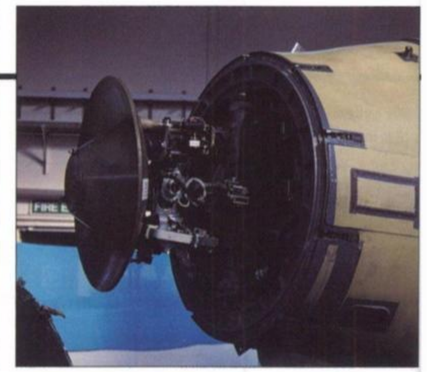
Right: Two views of the Ferranti Blue Parrot radar show the unit mounted in the aircraft and removed. The entire unit folded with the radome.





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50 Datalink inboard pylon
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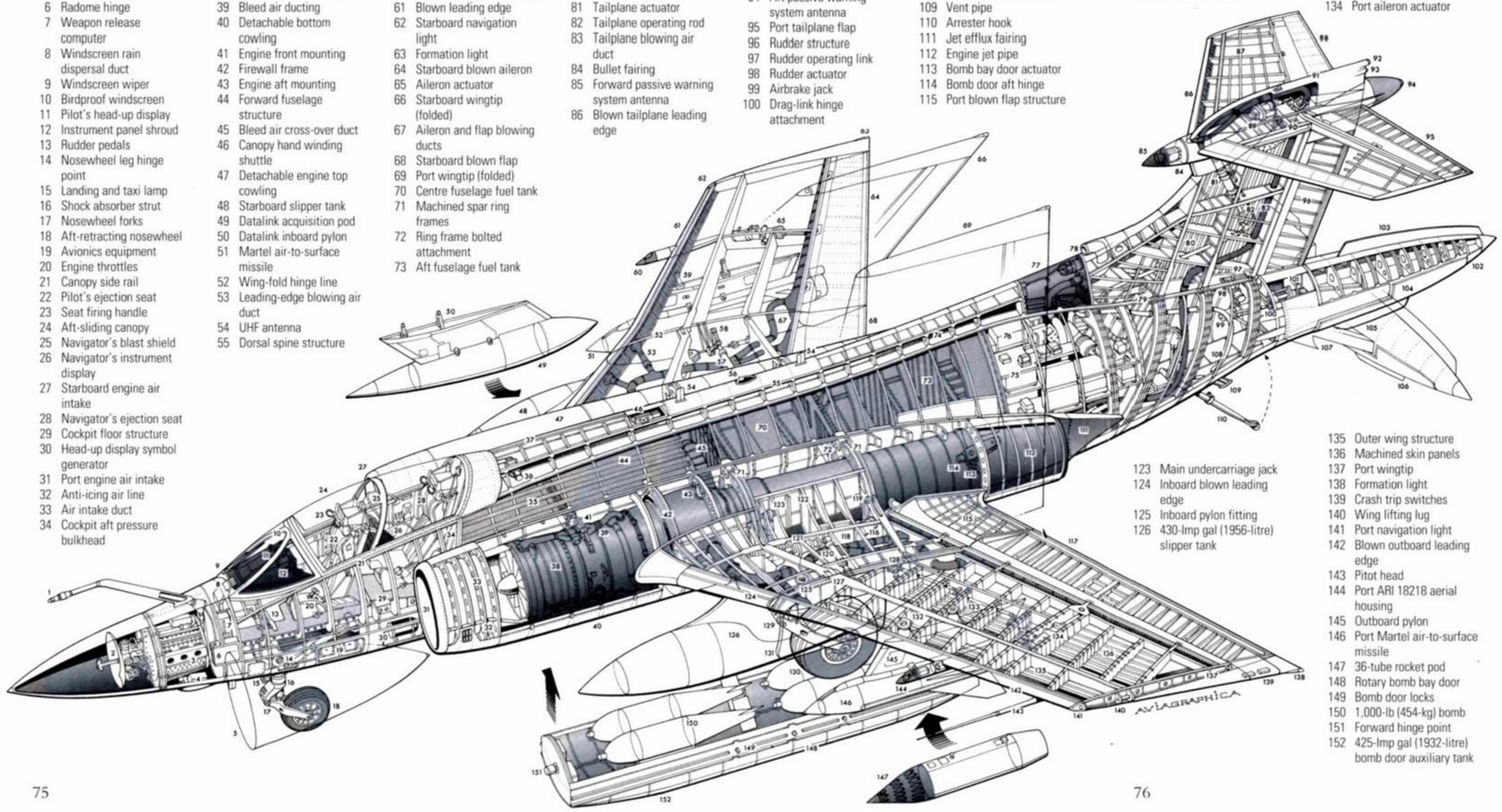
107 Hinge arm
108 Aft fuselage structure
109 Vent pipe
110 Arrester hook
111 Jet efflux fairing
112 Engine jet pipe
113 Bomb bay door actuator
114 Bomb door aft hinge
115 Port blown flap structure
116 Flap actuator
117 Port blown aileron
118 Blowing air duct
119 Wing spar bolted attachment
120 Wing-fold actuator
121 Top of main undercarriage leg
122 Mainwheel well
123 Main undercarriage jack
124 Inboard blown leading edge
125 Inboard pylon fitting
126 430-Imp gal (1956-litre) slipper tank
127 Wing-fold main spar hinge
128 Rear spar hinge
129 Main undercarriage levered suspension
130 Inboard retracting mainwheel
131 Mainwheel door
132 Outboard pylon fitting
133 Aileron operating rod
134 Port aileron actuator
135 Outer wing structure
136 Machined skin panels
137 Port wingtip
138 Formation light
139 Crash trip switches
140 Wing lifting lug
141 Port navigation light
142 Blown outboard leading edge
143 Pitot head
144 Port ARI 18218 aerial housing
145 Outboard pylon
146 Port Martel air-to-surface missile
147 36-tube rocket pod
148 Rotary bomb bay door
149 Bomb door locks
150 1,000-lb (454-kg) bomb
151 Forward hinge point
152 425-Imp gal (1932-litre) bomb door auxiliary tank



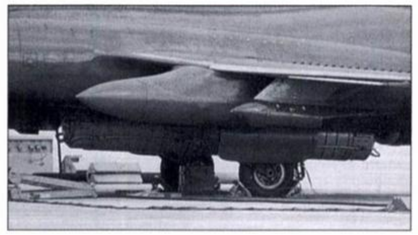
Above left: The FRL Mk 20 refuelling pod was always carried on the inner starboard pylon. Note the ram air turbine on the front which generated all the power necessary to operate the refuelling equipment.

Above right: The reconnaissance pack fitted into the forward part of the bomb bay. Here the windows for the forward-facing and side oblique F95 cameras are visible.

Right: Never used operationally, but always carried in conjunction with the reconnaissance crate to maintain centre of gravity, the flare pack could hold 198 flares. The recce/flare pack was often used to display slogans (typically 'Fly Navy') during air show routines.

By the end of the Buccaneer's career, aircraft sported four chaff/flare dispensers, two located on the inner side of the outboard pylon (left) and two aft of the arrester hook (above left). The latter were mounted either side of the lower rear RWR antenna.

Above: This view highlights the 22 vortex-generating vanes on the outer wing panel which energised the boundary layer. As illustrated, the wing-fold mechanism doors were often removed for easy inspection, even before the Red Flag accident.



Above: This No. 809 Squadron S.Mk 2 is fitted with the auxiliary fuel tank in the bomb bay, in addition to inboard pylon slipper tanks.

Above: A drop-down cargo pannier was developed for the bomb bay, able to carry spares or crew baggage. Golf clubs fitted with ease!

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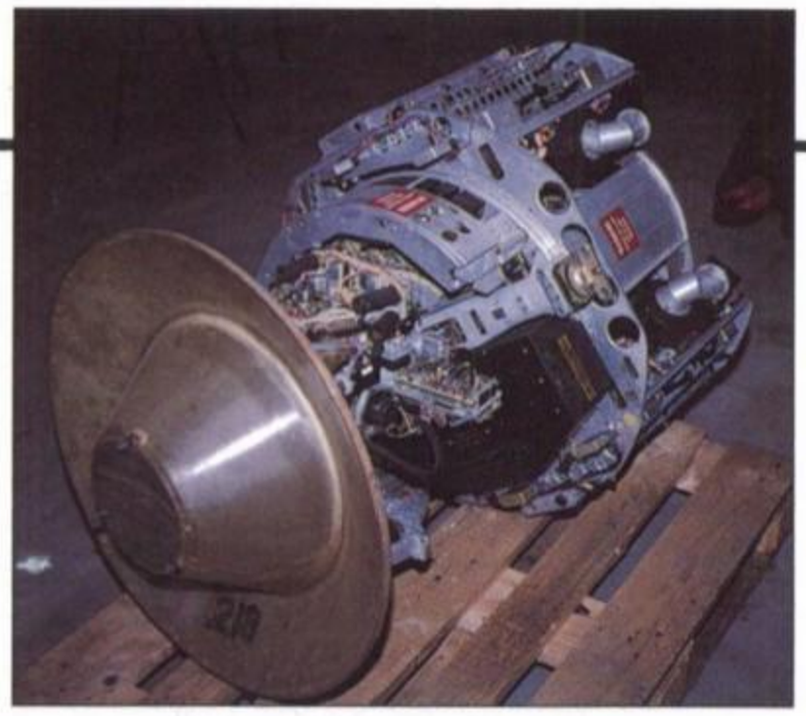

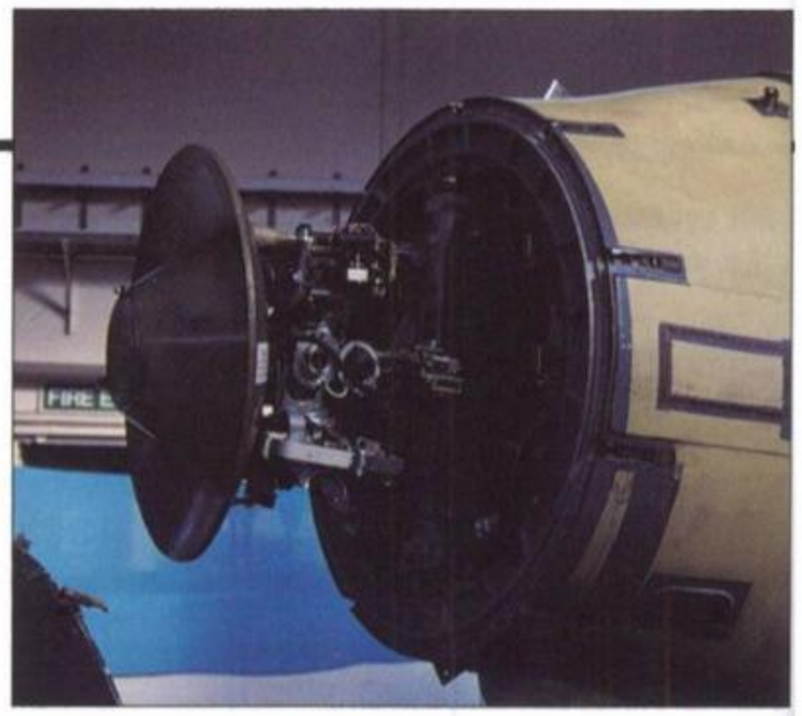

116 Flap actuator
117 Port blown aileron
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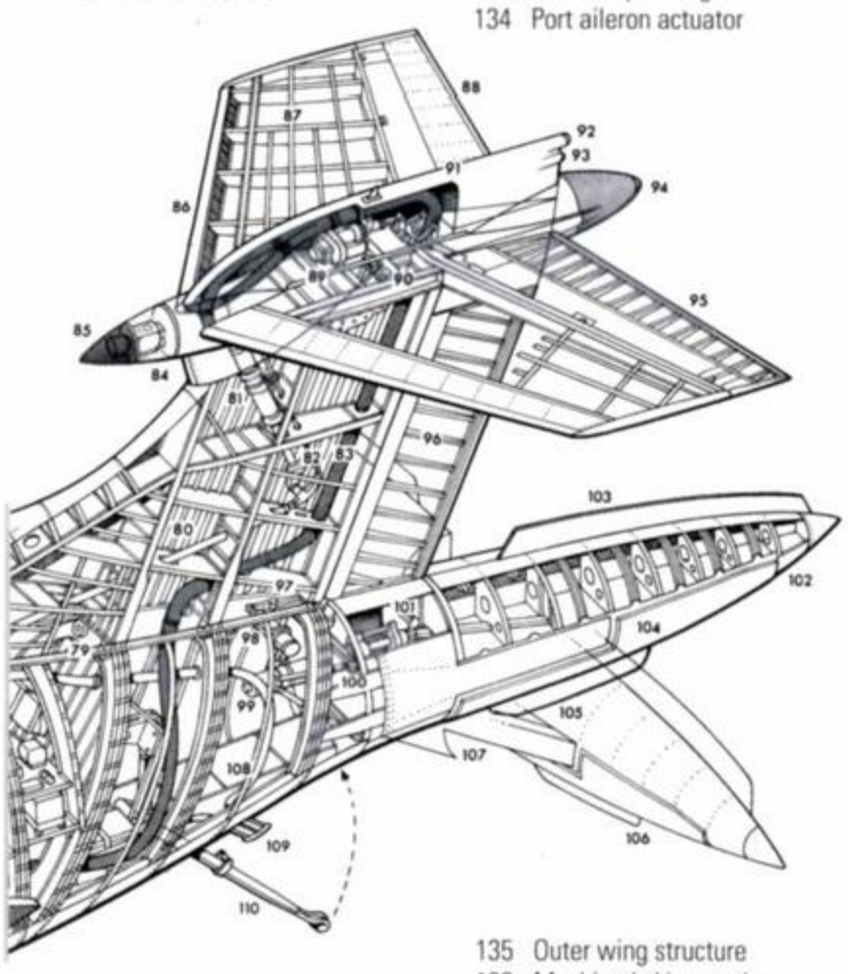
119 Wing spar bolted attachment
120 Wing-fold actuator
121 Top of main undercarriage leg
122 Mainwheel well



123 Main undercarriage jack
124 Inboard blown leading edge
125 Inboard pylon fitting
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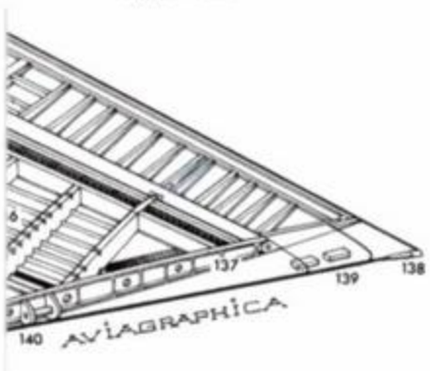

127 Wing-fold main spar hinge
128 Rear spar hinge
129 Main undercarriage levered suspension
130 Inboard retracting mainwheel
131 Mainwheel door
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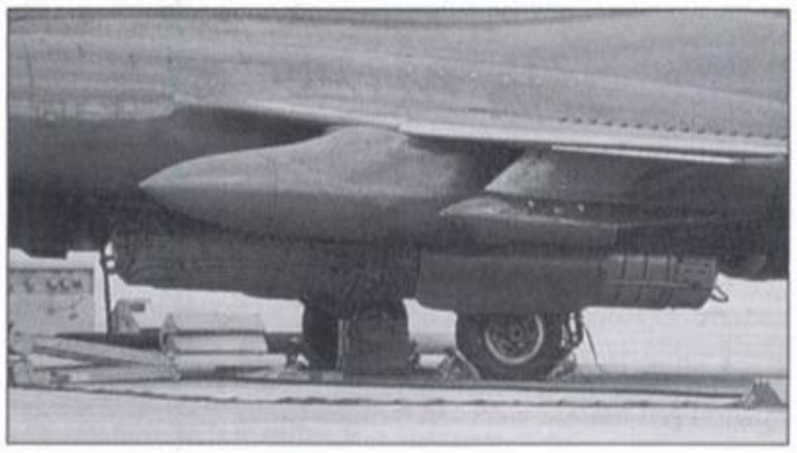

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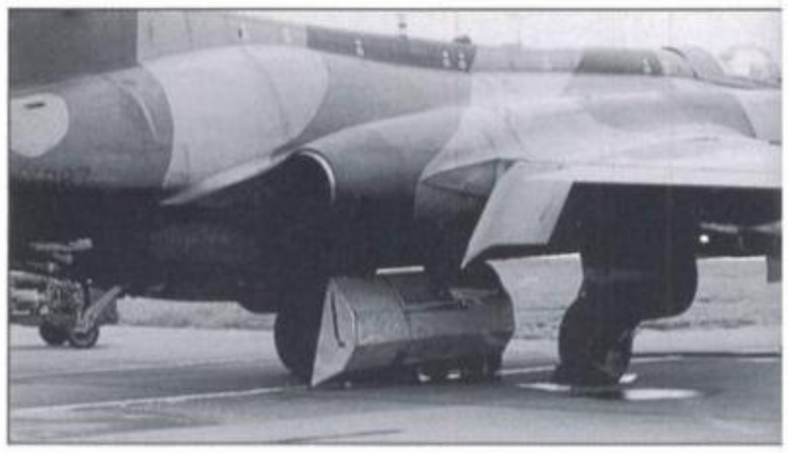

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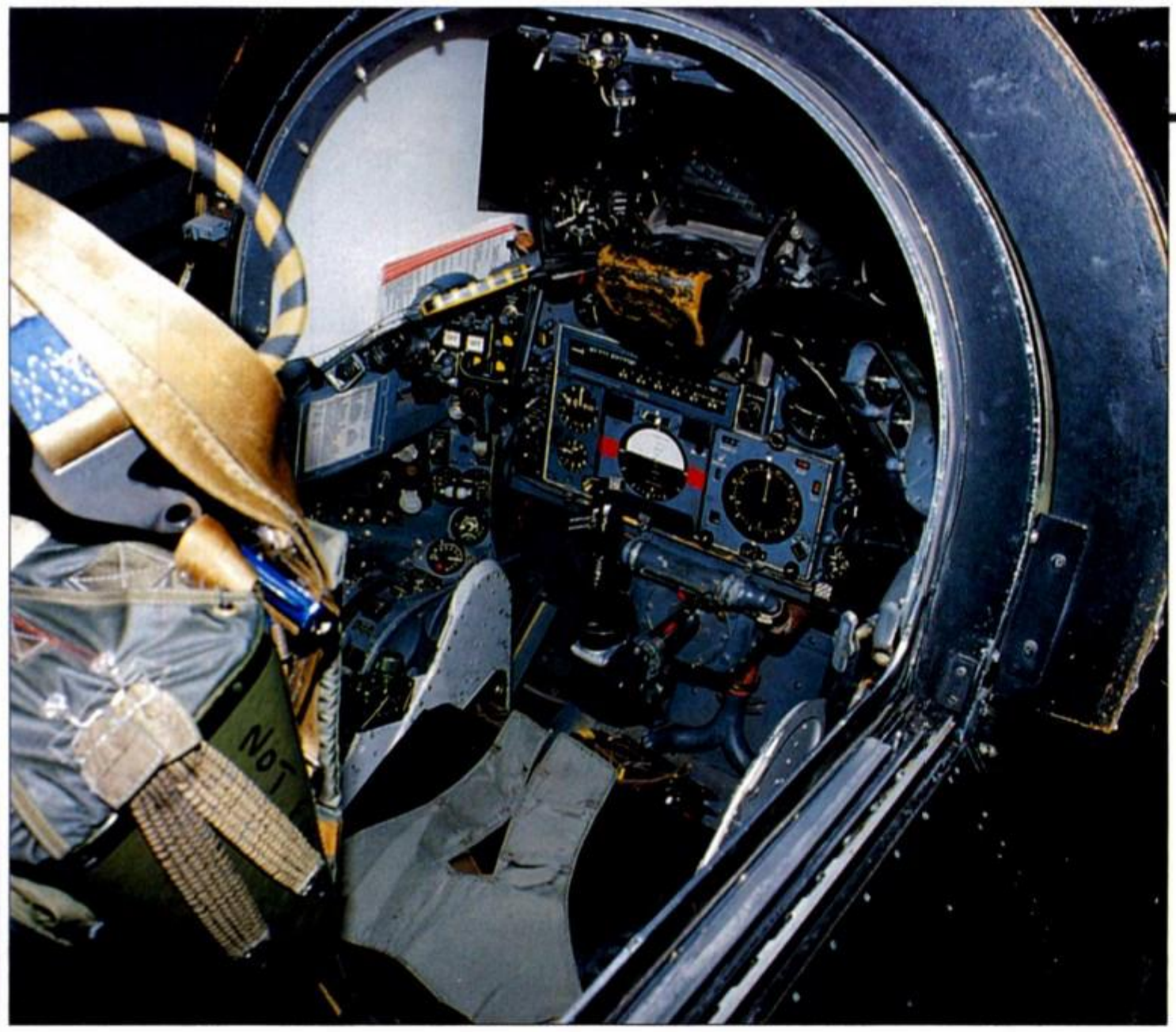
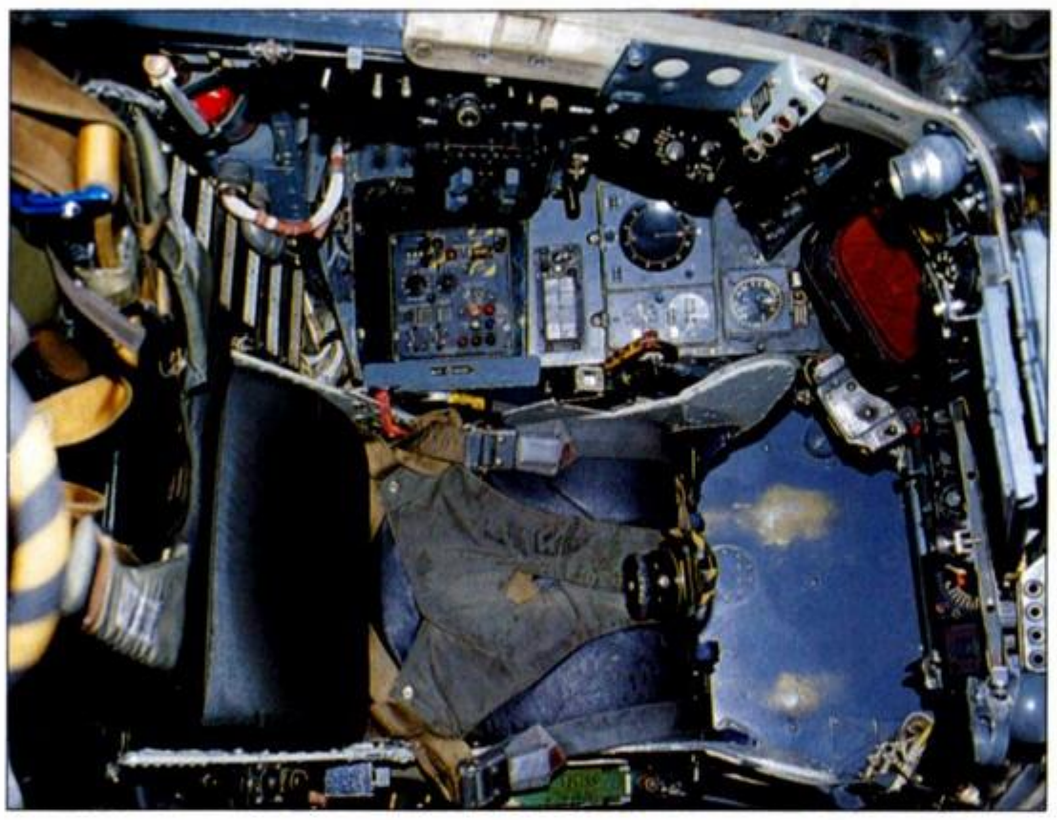


Above: This is the front cockpit of the Buccaneer simulator. Notable features are the weapons sight and the control column, which projects from the lower part of the dashboard rather than hinging from the floor. The central instrument is the attitude indicator, above which is a strip indicator for airspeed, calibrated in both knots and Mach number.

Right: The rear cockpit was dominated by the radar screen, offset to port. On Martel aircraft a central console was added with a small stick controller and screen, also used by the Pave Spike equipment.



Specification

Buccaneer S.Mk 1

Powerplant: two de Havilland (Bristol Siddeley) Gyron Junior Mk 101 turbojets, each rated at 7,100 lb (31.59 kN) thrust at sea level

Weights: empty 29,980 lb (13600 kg); maximum take-off 45,000 lb (20412 kg); maximum weapon load 8,000 lb (3629 kg)

Dimensions: wing span 42 ft 4 in (12.90 m); wing span (folded) 19 ft 11 in (6.07 m); wing area 508.5 sq ft (47.24 m²); tailplane span 14 ft 3 in (4.34 m); tailplane area 75.52 sq ft (7.02 m²); length 63 ft 5 in (19.33 m); length (folded) 51 ft 10 in (15.80 m); height 16 ft 6 in (5.03 m); height (wings folded) 16 ft 8 in (5.08 m); wheelbase 20 ft 7½ in (6.29 m); wheel track 11 ft 10½ in (3.62 m)

Performance: maximum speed at sea level Mach 0.85 (560 kt; 645 mph; 1038 km/h); range 1,730 miles (2784 km)

Buccaneer S.Mk 2B/S.Mk 50

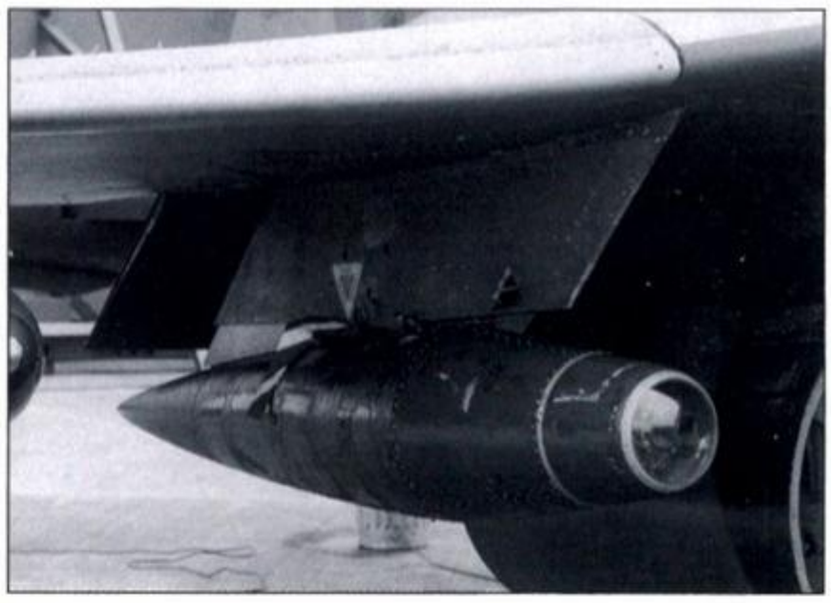
Powerplant: two Rolls-Royce RB.168-1A Spey Mk 101 turbofans, each rated at 11,030 lb (49.08 kN); S.Mk 50 had additional Bristol Siddeley BS.605 rocket motor developing 8,000 lb (35.6 kN) thrust for 30 seconds

Weights: maximum take-off 62,000 lb (28123 kg); maximum weapon load 16,000 lb (7258 kg)

Dimensions: wing span 44 ft 0 in (13.41 m); wing span (folded) 19 ft 11 in (6.07 m); wing area 514.7 sq ft (47.82 m²); tailplane span 14 ft 3 in (4.34 m); tailplane area 75.52 sq ft (7.02 m²); length 63 ft 5 in (19.33 m); length (folded) 51 ft 10 in (15.80 m); height 16 ft 3 in (4.95 m); height (wings folded) 16 ft 8 in (5.08 m); wheelbase 20 ft 7½ in (6.29 m); wheel track 11 ft 10½ in (3.62 m)

Performance: maximum speed at sea level Mach 0.85 (560 kt; 645 mph; 1038 km/h); take-off run at 46,000 lb (20865 kg) 2,360 ft (719 m), and 3,800 ft (1158 m) at 56,000 lb (25402 kg); landing run at 35,000 lb (15876 kg) 3,150 ft (960 m); range 2,300 miles (3700 km)

Buccaneer pods



Martel training pod – This consisted of an aerodynamically faired Martel seeker head which allowed the crew to practise target acquisition and attack. It was carried on the same rear-raked pylon as the datalink pod.

ALQ-101(V)-10 – This ECM pod was carried on the outboard pylons to provide protection across a wide band of frequencies. Note also the wing antenna for the Sky Guardian 200 RWR system.

Pave Spike – Always carried on the port inboard pylon, the AVQ-23E laser designation pod had its optics mounted in a gimballed turret. The lenses were protected against damage by a shield when not in use.

IRCM – Seen on an RAE Buccaneer is the Northrop AAQ-8 infra-red countermeasures pod, not adopted for the fleet. The pod turned ram air turbine power into pulses of infra-red energy to deter heat-seeking missiles.

Left: A quartet of No. 208 Squadron Buccaneers is seen over the Nevada desert at an uncharaceristically high altitude during a Red Flag in November 1978.

Above: No. 208 Squadron's aircraft were given a temporary dark earth/light stone desert scheme in 1977, although they retained a green/grey radome and rear fuselage. The paint baked on in the Nevada sunshine, and proved difficult to remove.

Seen in 1978, a No. 208 Squadron jet gets airborne from Nellis. The wrap-round scheme was applied as a result of Red Flag experience.

In the final years of Royal Navy operations there were precious few UK 'national' (i.e. colonial) interests remaining, so **Ark Royal** *and its complement were dedicated to Cold War NATO operations, operating in the north Atlantic and Mediterranean. This No. 809 Squadron Buccaneer is seen overflying the Norwegian fjords.*

Red Flag

Buccaneers were first deployed to Nellis for Red Flag 77-2, in the course of which the RAF crews astounded their USAF hosts with first-pass bombing accuracy and operations at very low level, earning the nickname 'Dirt Eaters'. Following the 1980 grounding, Buccaneers returned to Red Flag until 1983, the last detachment providing 'spiking' for Jaguars.

in the early years, later supplanted by MATRA SNEB with 18 rockets per pod. SNEB went out of the inventory with the arrival of the Hunting BL755 CBU (Cluster Bomb Unit), and No. 15 Squadron flew its final SNEB sortie on 31 July 1973. BL755, which gave greatly improved capability against armoured vehicles, contained 147 'bomblets' in a casing which approximated in size to that of a single 1,000-lb HE bomb, thus permitting the carriage of up to eight on a Buccaneer. Although RAF Germany's S.Mk 2Bs were Martel-capable, this weapon was not held in the inventory, and was not applicable to the squadrons' overland role in Central Europe.

Their commitment to NATO QRA meant that the Laarbruch squadrons did not, in general, deploy away from their home base for operations. Exceptions were made for weapons camps at the NATO range at Decimomannu, Sardinia, annual squadron exchanges with other NATO units and occasional deployments to the USA for Exercise Red Flag.

The American Westinghouse AN/ALQ-101(V)-10 active ECM pod became available to all the squadrons from 1976, and was carried on an outer pylon. While of a fairly primitive design, this active jammer – along with the internal passive warning receivers – gave the Buccaneer improved self-defence capability, especially in the era before the adoption by the RAF of air-to-air missiles on the type. Only minor 'tweaks' were made to the Blue Parrot radar, rather than the more major modifications and upgrades suggested by the squadrons as a result of their experience. Modifications were made to improve target resolution, MRE (monopulse resolution enhancement) upgrades gave a better low-level capability, and a new target marker was fitted to the radar. In the event, RAFG squadrons developed radar navigation to give a near all-weather capability in the strike – if not in the attack – role.

Back in the UK, No. 208 Squadron formed on 1 July 1974 as the fourth RAF Buccaneer squadron. It was initially AFNORTH-assigned, with Norway its chief wartime area of operations.

Bomb door tank

The development history of the Buccaneer is littered with schemes which were proposed, but never followed through, often for reasons of funding. The triple-ejector pylon, for which much development work was done and which would have given the S.Mk 2B the ability to deliver 16 1,000-lb bombs, was never used in service. Replacement of Blue Parrot by a Ferranti forward-looking radar with terrain-following capability was another proposal which was rejected, in this case seemingly because the RAF did not want to give the Buccaneer a capability which came too close to that of the forthcoming Tornado IDS. One improvement which did make it to the front line, to the point of becoming standard fit, was the bomb door tank. For aerodynamic reasons, the S.Mk 2B could not be fitted with the S.Mk 50's 430-Imp gal (1955-litre) underwing tanks. An ingenious alternative was devised in the form of an integral, 425-Imp gal (1932-litre) fuel tank, mounted on the bomb bay door and presenting a bulged

In the 1970s No. 809 Squadron made several shore visits to US Navy bases, notably Cecil Field in Florida. Here a Martel training pod-equipped S.Mk 2D taxis at Cecil during 809's last cruise in 1978.

profile which added only marginally to total airframe drag. For yet more range, a 440-Imp gal (2000-litre) fuel tank could be mounted inside the bomb bay itself. The bomb door tank modification was first flown on XV350 in early 1970, and was incorporated from 1974 into new-build S.Mk 2Bs and then retrofitted to existing RAF aircraft. Its adoption improved radius of action and, for certain sorties, freed up valuable underwing pylons for other stores. With all tanks fitted (two underwing, bomb bay and bomb door), the Buccaneer had a ferry range of around 2,300 nm (2,645 miles; 4257 km) at high level – the equivalent of Hawaii to San Francisco.

Contrary to some published sources, the incorporation of a bomb door tank was not in itself a defining feature of the S.Mk 2B. Some S.Mk 2As were similarly retrofitted.

Standardisation

As already discussed, the RAF's Buccaneer fleet was initially a mix of S.Mk 2As and S.Mk 2Bs, with a sprinkling of interim aircraft. The pace of deliveries from Brough in the mid-1970s allowed a degree of standardisation to be achieved by the modification of most RAF aircraft to full S.Mk 2B standard. This programme, which involved bringing aircraft at least up to Mod 1188 and Mod 1499 standard, was undertaken either at the Sydenham MU or by the manufacturers at Brough or Bitteswell. New-build deliveries and conversions permitted the complete re-equipment of No. 12 Squadron with S.Mk 2Bs, to allow it to train on Martel for its anti-shipping role.

In-service trial firings of Martel in both its TV and AR versions were undertaken in 1974. Two AR missiles were fired successfully over the French range at Cazaux, while aircraft from both Nos 12 and 809 Squadrons undertook the TV Martel firings (as Exercise Mistico) on the Aberporth Range. The missiles were launched under strict range control from Aberporth against either an old Royal Navy hulk or a 20-ft (6-m) square target.

The profile for a TV Martel attack was for the Buccaneer to fly towards the target at 200 ft (60 m) above the sea and to launch at 10 nm (11.5 miles; 18.4 km). The missile then climbed to 2,000 ft (610 m) and, at about 2 nm to run, the navigator, on seeing the target, would select 'terminal phase' and control the dive of the missile onto the target. On average, miss distances were within 10 ft (3 m), although the missile did not always perform according to the manufacturer's specifications. A navigator recalls, "On one memorable occasion, when the 12 Squadron navigator selected terminal phase, the TV Martel went into a vertical climb and disappeared through the complete cloud cover that was above the range. Unfortunately, a Phantom from Leuchars, who had been (as part of another CTTO trial) attempting to lock on to the TV Martel whilst it was in flight, was overhead at the time and was startled and discomforted by the sight of a 12 ft telegraph pole passing his starboard wing at not too great a distance. Needless to say, that was the end of that trial and he scuttled off back to Leuchars with his tail between his legs."

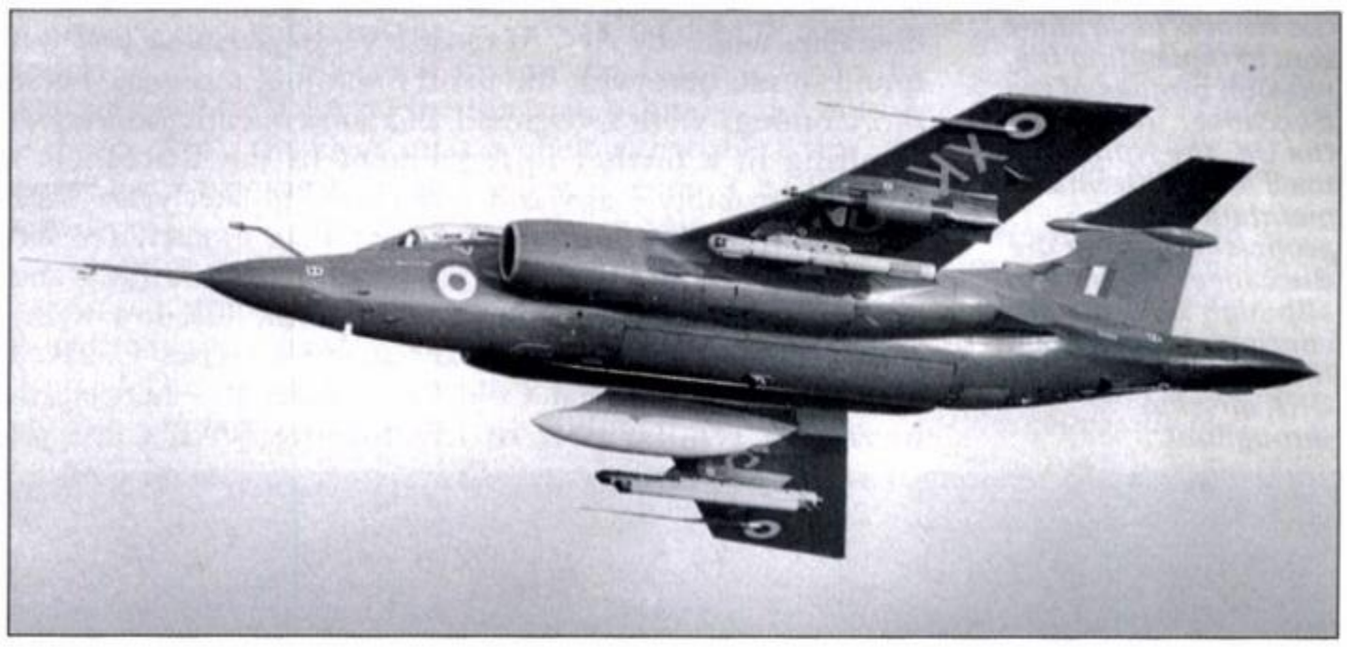
Vietnam demonstrated all too graphically to the USAF that the war they were fighting was not the one for which they had trained. While such self-delusion could not conceivably have occurred within the British defence establishment, the RAF's combat training had, by the mid-1970s, become somewhat stereotyped. For the Buccaneer force, the opportunities for realistic low flying and for the employment of ECM and live weaponry on exercise had become extremely limited in Europe. For the maritime squadrons, a degree of frustration was felt at the frequent exercise employment of their aircraft to simulate Soviet anti-shipping missiles and to make low-level attack against Royal Navy warships, seen by the aircrew as using the Buccaneer more for the Navy's benefit than for their own.

The USAF took the bold action to introduce large-scale training exercises using the vast tactical weapons and EW ranges in Nevada, with participating aircraft operating primarily from Nellis AFB. This was Red Flag, which started in 1975. Its reputation quickly spread, and the RAF eagerly accepted an invitation to participate in Red Flag 77-2 in August 1977. Ten Buccaneers of No. 208 Squadron, along with two Waddington Vulcans, comprised

Above: For the UK squadrons, air-to-air refuelling was an everyday part of operations, allowing anti-ship missions to be extended way out into the Atlantic. Here the tanker is a Victor K.Mk 2 of No. 57 Squadron.

Left: This is a view from the back seat during buddy refuelling operations. Prior to hooking-up to the drogue, the pilot activated the inflight-refuelling system with a switch. Fuel flowed into the aircraft's main internal tanks first: only when these were full did fuel then go into any additional tanks (bomb bay, bomb door, etc).

The two aircraft most associated with Pave Spike carriage trials were XK527 (below) and XW529 (bottom left), both operated by the manufacturer. These views show them with the AVQ-23 pod and a single 1,000-lb (454-kg) inert CPU-123 laser-guided bomb. XW529 also has cameras in wingtip fairings to record weapon separation.



Pave Spike

Buccaneers pioneered the use of laser designation within the RAF, courtesy of the Westinghouse AN/AVQ-23 Pave Spike system, carried on the port inner pylon. The Spike was used for both autonomous laser bombing and for designating bombs for other carriers. Pave Spike was acquired in 1979, primarily for use by No. 216 Squadron in the UK and by RAF Germany. The system had a gimbal-mounted TV camera (with boresighted laser) which provided imagery in the rear cockpit to allow designation. The system used the same screen and controller as the TV Martel system. The target was manually tracked by the navigator throughout the bomb's flight, the designator being turned on during the trajectory.

Hunter trainers

An integral part of the Buccaneer story was the use of two-seat Hunters for training purposes. No twin-stick Buccaneers were produced for training, so Hunter T.Mk 7/8s were converted with Buccaneer-style instrumentation in the left-hand seat to provide pilots with experience prior to their first 'fright' in the Buccaneer. The Hunters proved of enormous worth during the Buccaneer grounding, keeping pilot's hours up until the 'Bucc' was returned to service.

This selection shows various RAF Hunters, including those of No. XV Squadron (above), No. 12 Squadron (right and top) and No. 208 Sqn (above right). Both T.Mk 7s and T.Mk 8s were used, the latter being navalised aircraft with arrester hooks (for runway use only).

Accompanying a No. XV Squadron 'Bucc' on a low-level sortie past a radar site, WV318 was one of the F.Mk 4s converted to T.Mk 7 standard by Armstrong Whitworth. The four-tank fit was commonplace, enabling the Hunter to go some way to replicating the mission profiles of the Buccaneer. Just as in the UK, the Hunter was used in RAF Germany to maintain pilot proficiency during the Buccaneer grounding, although Buccaneers continued to maintain the SACEUR nuclear QRA mission throughout.

the RAF detachment, the Buccaneers deploying to Goose Bay, Canada for their ultra-low-level work-up.

Operating from Nellis in loose tactical formations of two or four aircraft, the Buccaneers demonstrated 'for real' against enemy ground defences and F-5 aggressors their capability to drop live weapons on the range from a first-run attack. The success of the Buccaneers in Red Flag certainly surprised the Americans – if not the RAF – and one contemporary account relates that "close observers say that the tactics adopted by the Buccaneer crews have astounded the USAF." Lessons were also learned by the RAF. For low-level manoeuvring, an all-over camouflage scheme was needed. The provision both of a self-defence missile capability and of chaff dispensers was also highly desirable, while the AN/ALQ-101(V)-10 jamming pod was found to interfere with the passive warning receiver. These shortcomings were recognised and subsequently addressed, resulting in a further improvement in the Buccaneer's combat capability – as was demonstrated in later years' Red Flags. Equally important, the Red Flag experience led directly to the RAF rethinking much of its training and exercise doctrine, and to an overhaul of the UK low flying system. Participation in overseas training exercises – in Red Flag and Maple Flag (at Cold Lake, Alberta) – henceforth became a regular part of life for the RAF's fast jet squadrons, to the great benefit of their operational effectiveness.

No. 809 Squadron, having RAF Honington as its shore base, received a batch of S.Mk 2Cs from March 1973 (the first was XT280 on 27 March), to be followed by Martel-capable Buccaneer S.Mk 2Ds from October. Since February 1972 and the disbandment of No. 736 Squadron, No. 809 had been the only FAA Buccaneer unit. Although the retirement date of HMS *Ark Royal* had been changed, its final run-down – and that of front-line fixed-wing flying in the Navy – had now achieved unstoppable momentum. In the ship's final years, an increasing proportion of the aircrew in the two fast jet squadrons of the air group were RAF aircrew on loan service, this figure reaching 50 per cent by 'the end'. Following a short work-up in home and Mediterranean waters in February/March 1978, the 'Ark' embarked on its last cruise, which was to see the ship calling at US East Coast ports before returning to the Mediterranean to make final visits to Piraeus, Naples and Malta. The fixed-wing aircraft of the air group left the carrier off Palma on 27 November 1978, the Buccaneers being flown to St Athan. Its final duties carried out, HMS *Ark Royal* paid off into reserve on 13 February 1979, while No. 809 Squadron had quietly disbanded at Lee-on-Solent on 15 December 1978.

The Navy's stores of AIM-9B Sidewinder AAMs, which had seldom been seen mounted on a Buccaneer, were then passed to the RAF at Laarbruch, where they were classified 'war emergency use' but were on occasions seen mounted on an outer pylon.

A fifth RAF Buccaneer squadron?

The AN/AVQ-23E Pave Spike laser designator pod had been purchased for the RAF in 1979, to give the RAF its first laser-guided bomb capability with Paveway LGBs. The release of the last Navy Buccaneers allowed the formation of the fifth RAF Buccaneer squadron: No. 216, whose speciality would be the LGB. Some corresponding modifications were required to the Buccaneer, and the first updated aircraft emerged in September 1979. The Pave Spike pod was fitted to the port inner pylon (no. 1) of an S.Mk 2B; because the system required a TV screen in the rear cockpit, only the Martel-compatible S.Mk 2B could be used. Aircraft deliveries to No. 216 got under way early in 1979, the squadron receiving mainly new-build S.Mk 2Bs but also a few ex-Navy S.Mk 2s, upgraded to S.Mk 2B standard. The squadron was working up to full operational capability in early 1980 when a Buccaneer crash occurred, which was to have far-reaching consequences on the whole Buccaneer fleet, and on No. 216 Squadron in particular.

S.Mk 2B XV345 was on the strength of No. 15 Squadron and taking part in the Buccaneers' third Red Flag exercise at Nellis AFB when it suffered a catastrophic

Gibraltar's North Front airfield was a regular destination for Buccaneers of both the Navy and RAF. This group of No. 12 Squadron aircraft was deployed in 1976 for Exercise Open Gate, a maritime exercise undertaken in the Gibraltar approaches and western Mediterranean.

failure of the starboard wing on 7 February 1980, resulting in a fatal crash on the range. As soon as the extent of the failure – which was in the front spar in the inner wing, adjacent to rib 80 – was discovered, the whole fleet was grounded. Some degree of incredulity was expressed, bearing in mind the squadrons' absolute belief in the Buccaneer's structural integrity, and early, unofficial reactions suggested XV345's crash might be a repetition of a latch pin fatigue fracture which had caused the loss of RAFG's XW526 on 12 July the previous year. Inspection of the aircraft at Nellis – and the remainder of the fleet back in the UK and in Germany – revealed a more serious problem, with two-thirds of the fleet showing similar damage in one or both inner wings. Worse, the incidence of the problem was virtually the same in ex-FAA and new-build RAF airframes, and seemingly bore no relationship to the role in which individual aircraft were employed. The RAF's participation in Red Flag had come to a temporary, but sudden, end. The aircrew at Nellis returned home by transport, although all but three of the Buccaneers were eventually ferried back to the UK. Two particularly badly affected aircraft – XV864 and XW538 – were returned in April by sea to Hull for examination. XV340, the fleet leader in terms of fatigue consumption, was taken by road from Laarbruch, loaded onto a barge at Emerich on the Rhine

and transported to Brough, where it arrived on 31 March for testing to destruction.

Hunters – keeping up flying hours

With Buccaneers grounded, the five squadrons had to find a means of keeping their pilots and navigators in current flying practice. Once again, the Hunter provided the answer. Six Hunter T.Mk 7s, ex-No. 4 FTS, were prepared and issued to the Honington squadrons to supplement the two-seaters already on the strength of the OCU. Others followed from the TWU at Brawdy and from the RAE. These proved invaluable during the six-month grounding of the Buccaneer, and several received squadron markings. No. 208 Squadron acquired six Hunters, including two single-seaters, some of which were fitted with four underwing tanks to increase endurance and to permit 90-minute sorties. All No. 208 Hunters were marked with the squadron's blue/yellow chevron, which probably had a positive effect on morale during a testing period. That the aircrews' sense of humour did not desert them in this time is evinced by a contemporary photo of the nose of a single-seat Hunter. The pilot is seated in the cockpit, while the navigator is sitting astride the fuselage, behind – and outside – the cockpit, the clear message being that there was 'no room for a navigator' in an F.Mk 6 – even if he was the squadron CO! If No. 208's experience was typical, pilots got seven or eight sorties a month during the grounding. At Laarbruch, the QRA was still held, and statements were issued that the aircraft would fly if required. Indeed, some limited Buccaneer flying – for reasons which remain unclear – took place from the base during the grounding.

Above: A No. XV Squadron Buccaneer flies at low level over a German canal. The RAFG nuclear mission envisaged Buccaneers making low-level attacks on key military targets such as airfields in East Germany.

Above left: In June 1981 Buccaneers from No. 208 Squadron took part in the five-day Tactical Bombing Competition, which involved four-ship attacks with live ordnance against targets at Otterburn. The Buccaneers did very well, but the exercise highlighted the need for meaningful defensive armament. The large numbers were worn on the fin to make easier the rare task of scoring kills by opposing Rapier batteries or fighters.

Below left: XW986, the first of the RAE aircraft, is seen on a test flight from HoSM. It was subsequently repainted, although XW988 retained the basic scheme throughout its career.

Below: XW987 also received a form of the MoD(PE) 'raspberry ripple' scheme. Here it is seen on a low-level sortie, doing what the Buccaneer did best.

RAE test fleet

Satisfaction with the Buccaneer for test purposes led to an order for three dedicated aircraft, delivered to the Royal Aircraft Establishment in early 1974. Resplendent in a yellow/black high-conspicuity scheme, the trio was involved primarily on weapons drop tests, using the RAE's West Freugh airfield for much of the time. The aircraft also operated from Farnborough. When RAE flying activities were grouped with those of the A&AEE, the Buccaneers moved to Boscombe Down, from where they continued to fly until the last retired in February 1995. From 1978 the fleet was joined by XV344, the 'Nightbird'.

Radar testbeds

The Buccaneer was employed as a radar testbed in three distinct programmes. First was the employment of XK487 (second prototype) by Ferranti for development of the TSR.2 radar, secondly two aircraft were converted as radar/systems testbeds for the Tornado IDS programme and lastly a single aircraft received Foxhunter radar and associated displays for the Tornado ADV programme.

Above: XX897 was procured specifically from late S.Mk 2B production for the Radar Research Establishment as a Foxhunter testbed. The aircraft wore this unusual mock-Navy camouflage.

Top: XT272 was one of two aircraft converted by Marshalls with the Tornado Nose Radar. A chin fairing was part of the conversion, used to test various equipment including the LRMTS (laser rangefinder and marked target seeker) fitted to Tornado GR.Mk 1s from Batch 3 onwards. Note also the test equipment in the bomb bay.

In RAF Germany Buccaneers were used to provide laser designation for themselves and other fleets, notably the Jaguars (under Option Lima). This is a No. XV Squadron aircraft, carrying the Pave Spike pod, in addition to an ECM pod and an AIM-9B Sidewinder. This elderly version of the 'Winder was inherited from the Royal Navy, and provided little in the way of meaningful self-defence. Note the hydraulic fluid streaking across the bomb bay door.

BAe investigations at Brough found several reasons leading to the failure. The new 'pointed' wingtips fitted to the S.Mk 2 had induced different loadings from those which had been used in calculations. Also, the fatigue test airframe at Brough was still an S.Mk 1, which in the event proved less than 100 per cent applicable to S.Mk 2 experience. XV340 was stripped down and tested to destruction, while S.Mk 2 XN982 was brought in to become the new fatigue specimen. Initial fears that, like the Valiant, the type might not be economically repairable proved over-pessimistic, and a 'donor' rework programme was instigated. The least severely affected airframes were modified, often involving the cannibalisation of other aircraft, and some 14 aircraft received inner wing transplants. Between 50 and 60 aircraft of the pre-crash RAF fleet of 90 were thus eventually returned to service. A second batch of a dozen aircraft was put into store at the Shawbury MU as a reserve, capable of being rebuilt if required (and, more importantly, if funded), while the worst affected airframes were put into long-term storage or released for instructional use, having been assessed as beyond economic repair.

Grounding order lifted

If this result was less severe than the worst expectations, it still resulted in a reduction of around one-third in the number of Buccaneers available to the squadrons. A government statement on 28 July 1980 announced the lifting of the grounding, and the rebuild programme continued while the squadrons' work-up to regain operational capability got under way in earnest. Priority in aircraft allocations was given to the RAFG squadrons and to No. 12 as the only operational maritime squadron, but, with the recovery of more aircraft than expected, No. 208's future with the Buccaneer was also confirmed. No. 216, however, did not continue with its formation.

The Secretary of State for Defence's statement indicated that around one-half the RAF Buccaneer force had exhibited no signs of fatigue, or only minor cracks which had already been repaired, although admitting that the RAF's Buccaneer declaration to NATO would have to be reduced. The service introduction of the Tornado IDS (GR.Mk 1) was, by that time, fast approaching, which would entail a contraction of the Buccaneer force from 1983/84.

No. 208 Squadron was the first to be declared operational, after a work-up lasting nearly six weeks. The other three squadrons followed, although squadron strength returned only slowly to the standard establishment of 12 aircraft, while the OCU restarted its courses. Fatigue monitoring became an ever more important task of the engineers on the Buccaneer squadrons from this time.

Return to Lossiemouth

With Honington earmarked for the Tornado Weapons Conversion Unit (TWCU) from 1981, a decision was taken to return the UK-based Buccaneer force to its spiritual home at Lossiemouth (RAF Lossiemouth, as it had been since 28 September 1972). First to move north was No. 12 Squadron, which left Honington in November 1980. The new location was ideal for the squadron's maritime role, putting it nearer its likely wartime operating areas and giving it better access to air-to-ground weapons ranges than was enjoyed by units based in East Anglia.

No. 208 Squadron and the OCU initially remained at Honington. With the demise of No. 216 Squadron, their Pave Spike equipment had passed to No. 208 for its overland role. The RAF Germany squadrons, Nos 15 and 16, had also received Pave Spike and continued to operate with it until their re-equipment with Tornados. These three squadrons all used Pave Spike to designate for 'bomber' aircraft, equipped with the required Paveway 1,000-lb bombs. The RAF used Paveway II(UK) from Texas Instruments – a British 1,000-lb bomb with Paveway seeker and tail. No. 208 was tasked basically with designating for its own squadron aircraft, while the RAFG Buccaneers 'spiked' for other Buccaneers or for RAFG-based Jaguar squadrons under Option Lima. 'Spiking', though, does not seem to have constituted a large percentage of the training hours allocated to these squadrons, especially in RAF Germany.

The OCU also had its war role. Initially it was tasked, in the 1970s, with providing four strike-capable instructor crews to bolster the front-line squadrons in time of war. This changed in 1984, after the disbandment of Nos 15 and 16 Squadrons, to providing six Pave Spike-qualified crews to give a laser designation capability for the RAFG Jaguar and Tornado squadrons. The OCU – which was never allocated a 'shadow squadron' designation for its war role – was subject to TACEVALs, and had to generate its own aircraft and demonstrate its ability to deploy the required aircraft and support personnel to Germany. This represented the first independent war role for the OCU, and there is evidence that No. 18 Group was less than happy with the arrangement, which deprived the maritime force of these aircraft and crews. The OCU deployed from time to time to Laarbruch for station exercises and routine training, combining this with the more routine course flying. In the UK, airborne laser designation and weapons delivery was only permitted on the range at Garvie Island, Cape Wrath, although a Buccaneer navigator could practise tracking a target using his thumb controller (but without employing

For many years a familiar sight over West Germany, notably around the 'clutch' airfields (Brüggen, Laarbruch and Wildenrath) near the Dutch border, the Buccaneer left for the UK in 1983/84, providing a welcome influx of aircraft for the UK-based units.

the laser) anywhere in the UK low-level areas, and this could be analysed from the video taken of the navigator's screen.

The OCU had, in 1984, two non-Pave Spike-compatible S.Mk 2As and five Martel- and Pave Spike-compatible S.Mk 2Bs. In what was to become a standard Pave Spike fit, an S.Mk 2B would carry (on underwing pylons, from starboard outer to port outer) AN/ALQ-101(V)-10 ECM pod, 240-Imp gal (1090-litre) drop tank, Pave Spike designator pod and AIM-9G/L Sidewinder AAM.

By 1983, the UK-based Tornado GR.Mk 1 force was building up, allowing No. 208 Squadron to be switched to the maritime role. This change was effected in 1983, with the squadron moving north to join No. 12 at Lossiemouth on 1 July of that year, to come under the auspices of No. 18 Group. The OCU also relocated to Lossiemouth in October 1984, in a move which regrouped all the RAF's Buccaneers at one airfield to form the Lossiemouth Buccaneer Wing. Although the front-line squadrons were both equipped with the S.Mk 2B, and thus Martel-compatible, only No. 12 Squadron trained on both AR and TV versions of the weapon for anti-shipping operations, while No. 208 continued with free-fall weapons, AR Martel and Pave Spike.

Anti-ship operations

Anti-shipping attacks were largely conducted as multi-aircraft operations, a six-ship being typical for a large warship target. Maritime tactics (MARTACs) were developed to overwhelm a ship's defences by many missiles and/or bombs arriving simultaneously. Depending on the nature of the ship's defences, attacks were planned as single-axis (to swamp a particular sector) or as multi-axis (to saturate the overall defences). Where possible, the Buccaneers used the VASTAC (vector-assisted tactic) with target positional data supplied by a Nimrod maritime patroller. Alternatively, one Buccaneer could be dispatched as a radar 'probe', popping up to around 5,000 ft (1524 m) to locate the target with one sweep of the Blue Parrot. With an effective range of about 115 miles (185 km), the Blue Parrot was an excellent radar for this task.

Above: Rocket-armed Buccaneers of No. 12 Squadron make their presence known to a Soviet 'Kanin'-class destroyer.

The Buccaneer had respectable high/medium-altitude performance, but it was down low where the aircraft's attributes were most appreciated. Low-level attacks were routinely undertaken at 540 kt (navigators usually plotted attacks using speeds that were multiples of 60 to ease calculations) or faster, at which speed the aircraft was virtually uncatchable by fighters. The wing was highly loaded, resulting in a very smooth ride for the crew, while the control surfaces provided a more than adequate degree of agility, backed up by the very powerful airbrake should things get a little 'hairy'. This aircraft is an S.Mk 2A from 237 OCU, displaying the original short, deep pylons that typified non-Martel aircraft.

In RAF Germany, the end was clearly imminent for the two Buccaneer squadrons when the RAF introduced the Panavia Tornado GR.Mk 1 to squadron service (with No. 9 Squadron at Marham) in June 1982. In October 1981, No. 16 Squadron had deployed to the United States for Red Flag, crossing the Atlantic by the great circle route which did not require air-to-air refuelling. They routed Laarbruch – St Mawgan – Lajes – Gander – Seymour-Johnson – Bergstrom and then low level to Nellis AFB. During the final sector, the squadron flew a diamond nine at 1,000 ft (305 m) above the lip of the Grand Canyon – perfectly legally. The following year, Wing Commander Peter Norris, CO of No. 16 Squadron at Laarbruch, formed a five-ship Buccaneer display team known as the 'Black Saints'. The team led the RAF Germany airborne salute on 11 June 1982 at Rheindahlen for the Queen's Birthday celebrations, and appeared at air shows in Germany throughout that summer. No. 16 Squadron attended Red Flag at Nellis in December 1983, two aircraft providing 'spiking' capability for RAF Jaguars; this, though, was to be their last appearance with the Buccaneer. On 1 March the following year, No. 16 reformed as a Tornado user, so ending the Buccaneer's career in Germany.

Operation Pulsator

The situation in Lebanon in late 1983 led to a British government decision to send a force of six aircraft to RAF Akrotiri, to provide CAS to UK forces if required. The aircraft were drawn from Nos 12 and 208 Squadrons, while the crews selected were generally the more experienced ones who had previously flown in the overland role. This was Operation Pulsator. Pave Spike designators were taken with this detachment, along with Paveway bombs, but tactics were also developed to employ ground-based forward air controllers (FACs) to do the laser designation, this being deemed a safer option, should live attacks need to be made on the city of Beirut. In the event, no live attacks were ever necessary, but the detachment continued until March 1984. On 11 September 1983, two Buccaneers were dispatched to fly low level over Beirut, each carrying a single Sidewinder and an AN/ALQ-101(V)-10 ECM pod, as an indication that RAF forces were 'in place' and ready for action if required. One resulting photo – of a Buccaneer at 100 ft (30 m) over city roof tops, with a furled Union Flag in the foreground – was widely published in daily newspapers across the world. This demonstration showed the true value of deterrence, and also greatly assisted the morale of the British contingent.

A batch of 12 Lossiemouth Buccaneers received modifications for Pulsator, with AN/ALE-40 chaff dispensers fitted and provision made (on 11 of the 12) for AIM-9G or -9L Sidewinder AAMs. This was the first time that RAF Buccaneers had received a 'serious' missile self-defence capability, the earlier AIM-9B – which had been inherited from the Navy – having been comparatively rarely carried. First live Sidewinder firings from an RAF Buccaneer were made by No. 237 OCU in March 1987, from STCAAME at Valley.

Lossiemouth was the ideal base from which to conduct maritime operations against the Soviet Northern Fleet, with its position also allowing the based units to cover the south-western approaches (using the dispersal base at RAF St Mawgan, at which hardened facilities were built). At Lossiemouth, each front-line squadron occupied its own squadron area on the airfield, operating from a hardened complex which included nine HAS shelters and hardened operations block, fuelling and logistics. The Mk 3 HAS of the type built at Lossiemouth could accommodate two

Two photographs show one of the Pulsator Buccaneers at Akrotiri. The Pulsator aircraft carried the ALQ-101 ECM pods, and were also hastily configured to carry the AIM-9L Sidewinder. Additional defences came courtesy of ALE-40 chaff/flare dispensers. Note the enlarged 'last three' on the tail.

Pulsator

Six Buccaneers were dispatched to RAF Akrotiri on Cyprus in 1983 to provide support for British forces in Lebanon, if required. The aircraft were configured with Pave Spike and 1,000-lb (454-kg) LGBs, and given impressive defences. Only three missions were flown over Lebanon, show of force low-level sorties that overflew Beirut on 11/13 September.

Buccaneers operationally, the only restriction being that the front aircraft had to be towed out for engine start because of possible reingestion problems. One positive result of the Navy's requirement that the Buccaneer should fold sufficiently to fit on a standard 54-ft (16.5-m) carrier deck lift was that, with wings folded, radome folded back and airbrakes open, a HAS could be used to store (rather than operate) up to four aircraft.

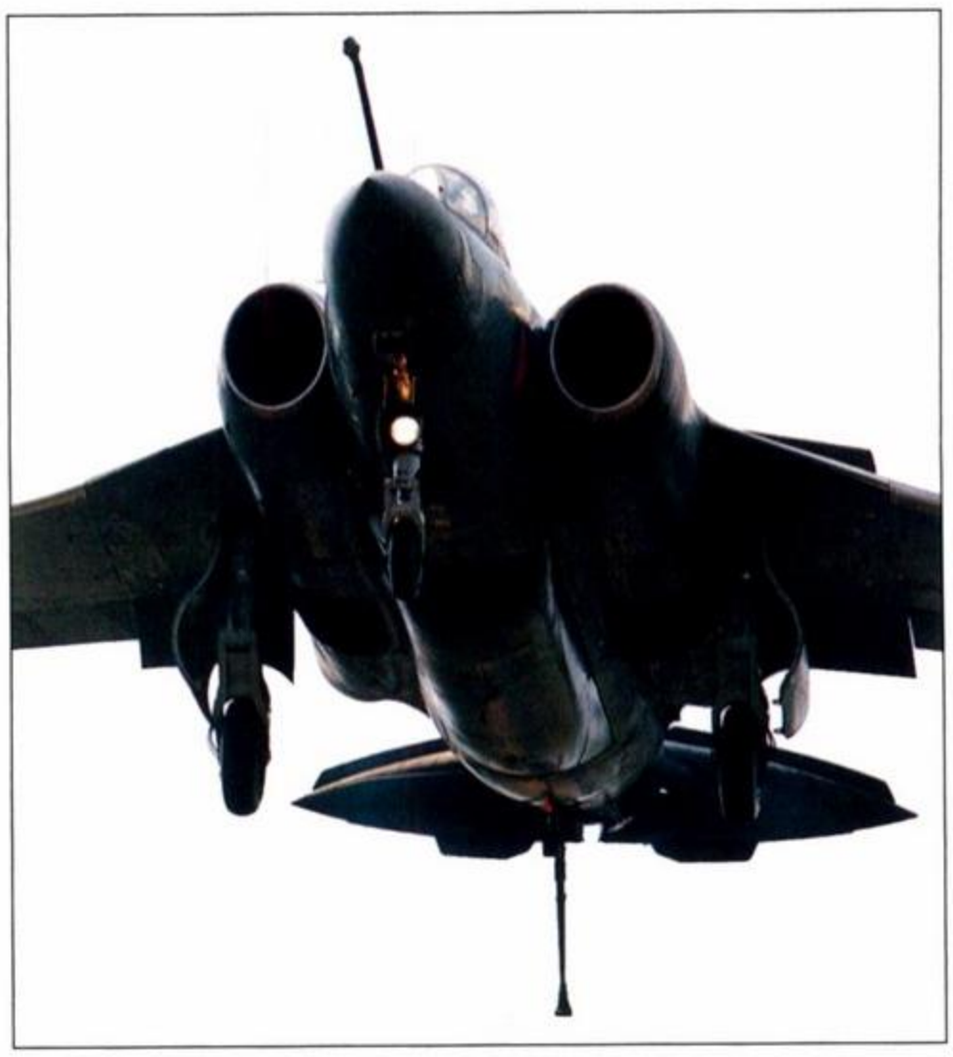
The threat facing the Lossiemouth Buccaneer Wing of the mid-1980s was clear. The developing Soviet 'blue water' navy was easily capable of interrupting lines of trade and the resupply routes between the eastern seaboard of the US and Europe. One could equally pose the question of whether Soviet intentions for the early days of a 'hot' war might have extended to an attack against Iceland, to gain control of the NATO air base and other defence assets located on that strategically placed but thinly populated island.

In-place and dedicated

Against this threat, the Lossiemouth Wing – of fewer than 40 aircraft – represented NATO's only in-place, dedicated maritime strike/attack force. True, the West German Bundesmarine maintained two wings (MFG 1 at Schleswig and MFG 2 at Eggebeck) of Tornados in northern Germany in the same role, but they had a primary parochial 'backyard' interest in the Baltic and southern North Sea. The word 'dedicated' is important in the specialised context of maritime strike/attack. While other NATO nations had (and still have) ground attack squadrons which could be 'earmarked' for the maritime role, it is arguable that nothing less than full-time training for the aircrew was likely to lead to the necessary degree of proficiency if the force were to be fully effective against a Soviet surface action group.

The tactics necessary to locate and attack heavily defended naval targets using low-level approach under radar silence had little in common with those required to carry out close air support or interdiction over the Central European plain, while the weapons employed were similarly specific to the maritime role. Another requirement for the force of attacking Buccaneers – which would have comprised a number of aircraft with a mix of weapons – was to receive coded VHF/UHF range and bearing information to the target from RAF Nimrods or NATO E-3As.

Much emphasis was put on ship identification in the Buccaneer squadrons, including details of each type's defensive armaments and their range, radars and ECM. Morning briefings by the squadrons were followed by a short recon-



Above: Buccaneers from No. 208 Squadron are seen flying from Cold Lake, Alberta, during the 1980 Maple Flag exercise.

Left: With everything dangling, the Buccaneer still looked every inch a carrier aircraft even in the last days of its RAF career.

Below: A No. 237 OCU Hunter leads a pair of Pave Spike-equipped Buccaneer S.Mk 2Bs. Use of the Pave Spike laser designator became the OCU's war role from 1984, largely on behalf of the RAFG Tornados but later extended to other users, including the F-16As of the KLu's 311 Squadron. In the era of unit tailcodes, the OCU adopted the codes 'xC', the 'C' standing for Cutlass, the unit's callsign.

Blackburn Buccaneer

Right: The first RAF Buccaneers were cleared to carry the AIM-9G and AIM-9L Sidewinder in 1983 for Operation Pulsator, and the modification was subsequently applied to most of the fleet. Here a No. 237 OCU aircraft fires the Buccaneer's first upgraded missile, an AIM-9G, at STCAAME (flying from Valley) in 1987. At first the 'Golf' was the main weapon, as priority in supplying the far more capable 'Lima' naturally went to the air defence units.

Above: ALE-40 chaff/flare dispensers were added beneath the Buccaneer's jetpipes to provide protection against missile attacks. Here, infra-red decoy flares are ejected.

Right: Seen at the moment of brake release, a No. 12 Sqn pair takes off from Lossiemouth. The Morayshire base offered generally excellent flying weather (by UK standards).

naissance update and test. An altogether higher degree of dedication was exhibited in the toilets in the operations blocks, where ship recognition photos were pinned to the inside of the cubicles, along with current copies of service recognition journals, for study in those 'spare minutes'.

In a 1988 interview with Wing Commander Keith B. Moore, boss of No. 12 Squadron, the author questioned whether the maritime role might be adequately covered by some of RAF No. 1 Group's Tornado GR.Mk 1 squadrons as a secondary role. Moore's reply was unequivocal: "There is no way that Strike Command Tornado squadrons could do this as a secondary role and achieve the same level of proficiency that we do. The Tornado squadrons are already very busy in their primary roles, training to fly and fight over land and maintain a capability against land targets and associated defences."

As might be expected from an aircraft with its ancestry in the late 1950s, the Buccaneer cockpit – designed before current trends towards ergonomics – was becoming somewhat of an anachronism in the aircraft's later service life, being complicated by a number of 'add-on' pieces without any major redesign or rework. This was particularly true in the rear cockpit, where the navigator sat with the Martel TV screen between his legs, radar to the left and GPI/GPIC navigation equipment to his right. Lossiemouth crews got used to long sorties; their operating area could well be many hundreds of miles north of the British mainland, and training sorties were planned to give sufficient Victor tanker slots to keep up proficiency. Unrefuelled, the Buccaneer could go a long way, while inflight refuelling extended this range to the limits of crew endurance.

The S.Mk 2B had a basic internal fuel capacity of 12,500 lb (5670 kg) and almost 4,000 lb (1814 kg) in the bomb door tank, bringing the total to roughly 16,000 lb (7260 kg). The addition of either a pair of slipper tanks on the inner stations or an additional tank inside the bomb bay brought the fuel load to a maximum attack capacity of 20,000 lb (9070 kg). In practice, the internal bomb bay tank was only used for ferrying, while wing tanks were used less frequently in later years due to the need to free up pylons for weapons, especially in the maritime role.

Martel attack

The TV Martel was powered by a solid-propellant motor and had a TV camera in the nose. Immediately after launch, the missile followed a pre-programmed trajectory, but final guidance was effected by the navigator, who steered the missile using a small control column in the rear cockpit. Although Martel was subsonic and thus theoretically vulnerable to short-range ship-mounted SAMs or even to radar-laid rotary cannon of the Phalanx type, the Lossiemouth Buccaneer Wing trained to fly a six-ship co-ordinated attack, to launch a number of missiles concurrently and to achieve salvo compression, thus aiding missile penetration.

A typical maritime attack formation would comprise two elements, each of three aircraft, separated laterally by 2,000 yd (1829 m). The four lead aircraft would carry two TV Martels, the required datalink pod and an AN/LQ-101(V)-10 ECM pod – the 'CM fit'. Following up the rear would be two anti-radar (AR) aircraft, each carrying two AR Martels, an AIM-9G or -9L and an ECM pod – the 'CX fit'. The presence of AR-armed aircraft at the rear provided something of an insurance for the formation. Should the enemy ships have chosen to track the incoming Buccaneers on radar, they stood the chance of being on the receiving end of an AR Martel attack, while if they decided to shut down their radars then the Buccaneers had gained a significant tactical advantage. Some of the Buccaneers would also have carried two (up to four) 1,000-lb retarded bombs in the bomb bay. Like the Sidewinders, they were for self-defence. Should an enemy fighter get in behind the formation, the Buccaneer pilot, rather than turning to fight (in which case he might have failed in his objective of putting a Martel on the target), had the option of dropping a bomb from 100 ft (30 m), just ahead of the fighter. This was known as 'retard defence'. The following aircraft risked significant debris damage, and the shock effect was never to be underestimated.

Flying at 100 ft over the sea, the Buccaneer was in its element. With twin-Spey power, a Buccaneer 'on the deck' emitted little smoke and had a minimal IR signature. Pilots had complete faith in the radalt (radar altimeter), with the pressure altimeter being constantly updated because the

A No. 12 Squadron Buccaneer deploys the hose from the Mk 20 refuelling pod. The Buccaneer was a useful tanker, especially after the bulged bomb bay door tank was cleared for use, providing a useful increase in internal fuel capacity.

Sea Eagle

The BAe Dynamics Sea Eagle gave the Buccaneer force a true fire-and-forget capability. The missile was also a sea-skimmer, and was far more difficult to intercept than the TV Martel, which dived on to the target from about 1,000 ft (305 m). In fully-computed mode, the Sea Eagle downloaded a theoretical target position from the aircraft prior to launch.

Left: Old-stager XK527 was used as the carriage and flutter test vehicle for the Sea Eagle, seen here in June 1981. Four missiles was the standard fit, rather than a demonstration load (as opposed to the current Tornado GR.Mk 1B's two) and the Buccaneer could launch the Sea Eagle in fully-computed mode from the outset. A reversionary mode was also available in which the missile flew a pre-programmed profile, attacking the first target it saw when it activated its radar.

radalt did not give a true indication while banked in the turn. The run-in to target the was begun at 480 kt (552 mph; 888 km/h), accelerating to 540 kt (621 mph; 999 km/h) to launch missiles, followed by a gentle turn away from the target to maintain the datalink with the Martel. The formation's aim needed to be, as far as possible, to keep out of the radar detection range of the vessels being attacked, and to use the AR Martel to neutralise any radar picket ships.

By the early 1980s, though, the stand-off range of the TV Martel was becoming marginal when ranged against the increasing lethality and range of the radars and defensive weapons employed by the latest generation of Soviet warships.

Several policy decisions came to affect the Buccaneer force in 1983. Although earlier planning had envisaged the complete replacement of the Buccaneer by the Tornado in the mid-1980s, it was decided to keep the Buccaneer flying into the foreseeable future. Plans were announced to update a batch of Buccaneers to fit a new inertial navigation system, a HUD, improved ECM and to make the aircraft compatible with the new BAe Sea Eagle anti-shipping missile.

Sea Eagle – new-generation ASM

With a range of more than four times that of Martel, Sea Eagle is a true 'fire and forget' weapon which continues in use today. Receiving target information from the carrying aircraft prior to launch, the missile drops on launch to sea-skimming height and is completely autonomous, allowing the Buccaneer to make whatever egress manoeuvres are required. The missile's radar seeker remains silent until it comes within range of the selected target; the seeker is then switched on, and acquires the target. Sea Eagle was designed to work in an ECM environment, and to be able to single out a particular ship in a target group. The missile does not require a datalink pod, so a Buccaneer could carry four Sea Eagles on its four underwing pylons. With a 225-kg warhead (as against 165 kg carried by Exocet), Sea Eagle is capable of penetrating six bulkheads of a modern warship.

Its previous lack of an anti-shipping missile meant that No. 208 was the first to receive Sea Eagle. The provision of Sea Eagle compatibility was closely tied to an Avionics Update Programme (AUP) incorporated into a batch of 42 Buccaneer S.Mk 2B aircraft. An initial 10 aircraft were made Sea Eagle-compatible under a programme carried out at Lossiemouth between December 1984 and April 1986, although the modifications (Mods 1724 to 1727) made to these aircraft were limited. A second batch of 10 Buccaneers received the same modifications at the MU at St Athan while undergoing major servicing between April 1985 and September 1986.

Avionics Update Programme

The full AUP, or ASR 1012, got under way during 1986, and involved the Buccaneers being flown to the BAe factory at Woodford to receive a fairly major update package. Central to this was the fitting of an inertial navigation system, primarily for use in conjunction with Sea Eagle. The INAS selected was the Ferranti FIN 1063, a relatively low-cost option employing equipment similar to that used to update the Jaguar fleet. It replaced the old GPI and GPIC. A new Plessey ASR 889 radio was fitted, along with a digital Sky Guardian 200 radar warning receiver (RWR); this fit also included E-J band receivers in the former wing-mounted wide-band homer aerials. The planned HUD, though, fell victim to cost-cutting. Full Sidewinder AAM compatibility to mount AIM-9G or -9L was incorporated, along with some cockpit changes to facilitate operation by aircrew in full AR5 NBC clothing. As from the 10th aircraft, Tracor AN/ALE-40 chaff and flare dispensers were fitted – chaff dispensers on the side of the outer wing pylons and flares under the jetpipes – to replace the earlier temporary fit or the rudimentary solution sometimes adopted, which involved carrying a polythene pack with a

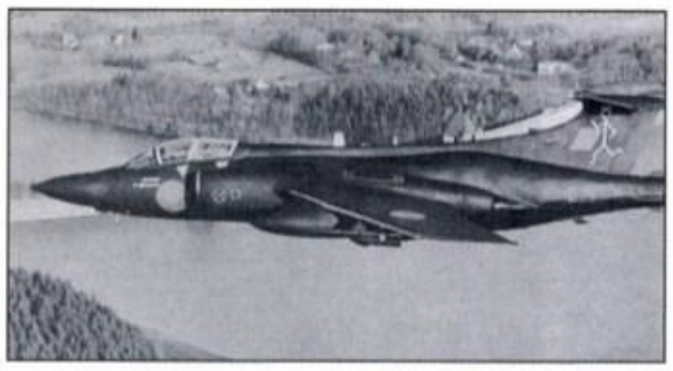
Above: No. 208 Squadron was the first to receive Sea Eagle, its modified aircraft pre-dating the full AUP programme. Dedicated pylons were needed, along with a cockpit control panel.

Above left: Seen in its typical operating environment, a Buccaneer carries four drill Sea Eagles. The operational missile weighed 1,323 lb (600 kg) at launch, of which 507 lb (230 kg) was the semi-armour piercing warhead, which could penetrate hulls even in a glancing blow.

For carriage the Sea Eagle had protective caps fitted over the inlet and jetpipe of the Microturbo TRI-60 turbofan, which blew off when the missile was released. A radar altimeter was used to fix cruising altitude.

Anniversary schemes

Below: No. 16 Squadron painted one of its aircraft (XT279) black all over and applied the squadron's adopted 'Saint' badge in yellow on the fin. The scheme lasted around a week before being ordered to be removed. The squadron briefly operated the five-ship 'Black Saints' display team.



No. 208 Squadron's 80th anniversary bird received a black scheme, with blue and yellow markings applied over the top. The original form (below) gave way to a more muted scheme (right). The Hunter was a Lossiemouth aircraft, painted black for the retirement of a former 'Black Arrow'.

XX894 was given these special markings for No. 12 Squadron's 75th anniversary. The scheme consisted of a green lightning flash over a mid-grey base.

bundle of chaff between the two halves of the airbrakes for one-shot use. The final 15 aircraft also reverted to the original Mk 1 wingtips, in a change intended to reduce fatigue. Since the start of the AUP, the Sea Eagle-compatibility modifications were made at the same time as those specified for ASR 1012. The first 20 aircraft, which had earlier received Sea Eagle-only modifications, later returned to Woodford to go through the AUP.

No. 208 Squadron was operational with Sea Eagle by the end of 1986, to be followed by No. 12 Squadron which received its first AUP aircraft (XV161) in December 1987 and similarly worked up to full operational capability with the new missile during 1988. Finally, the OCU also received AUP aircraft from late 1988, to the point where almost all Lossiemouth aircraft were AUP S.Mk 2Bs. With the completion of the AUP in 1989, the TV Martel effectively passed out of the RAF inventory, although the AR version remained an option for some years. One advantage which TV Martel offered was that it allowed the Buccaneer navigator a visual identification of the target right up to the point of impact. Of particular advantage in a limited war situation, this allowed the navigator in an attacking aircraft final-second verification that the target framed in the crosshair sight on his TV screen was an enemy warship rather than a supertanker.

The AUP Buccaneer S.Mk 2B with Sea Eagle armament was an excellent combination, with long range, self-defence capability and high kill probability against even well-defended ship targets. Ever since the introduction of Martel and the consequent 'pressure' for wing pylon availability to carry weaponry, RAF Buccaneers made less use of underwing tanks and more of air-to-air refuelling from the RAF tanker fleet. Buccaneer 'buddy' tanker operations were possible and, in later Lossiemouth days, a time-expired S.Mk 2A was configured with an underwing FR Mk 20 pod as a 'last gasp' Wing tanker, but AUP airframes were generally considered too valuable for regular use in this role.

During 1984 the Lossiemouth station commander decreed the adoption of two-letter codes by the based squadrons. No. 12 Squadron chose the '-F' range, with the 'F' indicating fox, from the squadron badge. No. 208 decided on codes in the '-S' range, referring to the sphinx from their badge. The OCU, after its move to Lossiemouth, opted for '-C', the letter standing for cutlass. (The OCU's crest was a pair of crossed cutlasses, and 'cutlass' was also one of its formation callsigns.) This system was maintained for a couple of years but, with the inevitable change-around of airframes necessitated by the AUP programme, the whole scheme became unworkable and was later replaced by the simple adoption of the 'last three' of the serial marked on the fin.

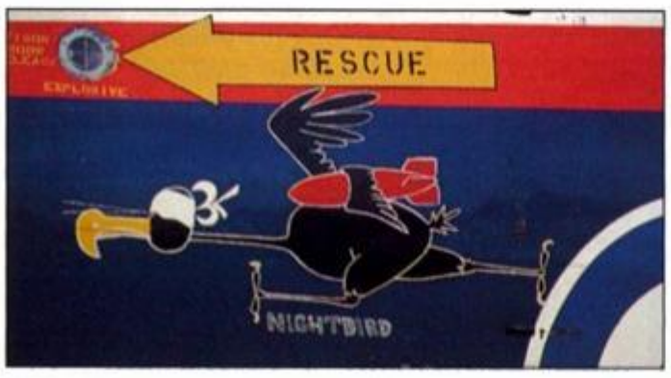
Into the 1990s

Although now a force reduced in size, the remaining Buccaneer S.Mk 2Bs of the Lossiemouth Buccaneer Wing featured in defence planning through to the mid-1990s, after which time the airframes' age and fatigue life would require a major rework if replacement were to be long delayed. Various alternatives were studied from the late 1980s, with a new-build 'maritime' Tornado F.Mk 3 (the extra fuel tankage being considered necessary for the role) being one contender. In the end, the disbandment of four RAFG Tornado GR.Mk 1 squadrons under Options for Change was to provide enough airframes to allow the replacement for the Buccaneer fleet from 1993 with the 'minimum change' Sea Eagle-equipped Tornado GR.Mk 1B.

Despite Royal Navy service which had taken the Buccaneers around the world, Operation Pulsator represented the nearest that the Buccaneer had come to a 'live' war, at least in terms of British operations. The type had not participated in the Falklands conflict of 1982, both because of the

Nightbird

One of the most important test programmes undertaken employing a Buccaneer was that involving XV344. Transferred to the RAE in 1979, it was used from 1982 in the TICM II (Thermal Imager Common Module) trials, fitted with forward-looking infra-red in a chisel nose and other equipment for low-level night flying, and known as the 'Nightbird'. It later incorporated laser technology and from its systems was developed the TIALD laser/FLIR targeting pod. Rudimentary flight controls (without rudder pedals) were fitted in the back seat for use by the safety pilot. Fittingly, the aircraft is now on display at DERA's Farnborough site, from where it flew most of its sorties.



QRA commitment and the need to maintain in-place the capability against the Soviet Navy. All this was to change in late 1990, when the Buccaneer was very much in its twilight years. No. 237 OCU had retained its wartime role of Pave Spike designation for LGB-equipped Tornado GR.Mk 1s of Nos 15 and 20 Squadrons, as well as for RNlAF F-16As of No. 311 Squadron, and had a number of Pave Spike-qualified crews.

Despite early assurances that the Buccaneer would not be required in the UK's Operation Granby build-up in the Persian Gulf in late 1990, the OCU accelerated its pace of overland Pave Spike training from November of that year. However, once the war started and Desert Storm got under way, the Lossiemouth Wing was called upon on 23 January 1991 to deploy an initial batch of six Buccaneers to the Gulf. Their purpose was to provide laser designation for RAF Tornado GR.Mk 1s, and 'to improve the standard of precision bombing'. The early RAF bombing attacks had been at low level with JP233. With much of the air threat neutralised, the bombing of Iraq could move to medium level. Only No. 237 OCU had previously trained for the overland 'spiking' role; aircrews with Nos 12 and 208 Squadrons had maintained Pave Spike currency, but primarily for their maritime role. The need in the Gulf was for a medium-level, overland 'spiking' capability to improve the accuracy of the Tornados' medium-level bombing.

Gulf modifications

Over the following three days, six S.Mk 2Bs received Have Quick II secure radios, an improved IFF and the now-familiar 'desert pink' overall paint scheme, and the first pair left Lossiemouth for the transit to Muharraq, Bahrain. All six – XX899/P, XX892/I, XW547/R, XW533/A, XX889/T and XW530/E – were in place by the end of the month. The detachment, under Wing Commander Bill Cope, styled itself the 'Sky Pirates', underlined by the code letters of the first batch of aircraft. Six further aircraft followed by 8 February, and all 12 received names and nose art during their stay, with all but one also acquiring 'Jolly Roger' badgework. Aircrews were drawn from both squadrons and from the OCU.

Following a quick in-theatre work-up over the Saudi desert with RAF Tornado GR.Mk 1s, the first war mission was flown on 4 February, involving two Buccaneers and four Tornados from Dhahran. Wing Commander Bill Cope flew the lead Buccaneer, with Squadron Leader Norman Browne as 'spike leader' navigator in the second aircraft, which was piloted by Flight Lieutenant Glenn Mason. Their target was a bridge across the Euphrates at As Samawah, which was located, laser-designated and destroyed by six LGBs with devastating accuracy. The second mission, again against bridges, was equally successful, and the video (from the navigator's TV screen) was shown nation-wide across the US on the evening news, which went some way to recognising the RAF's – and the Buccaneer's – contribution to the war effort. For this and the next few missions, the Buccaneers flew with a AIM-9L Sidewinder on the no. 3, port outer pylon, supplies of the latest '9 Lima' having been flown in to Muharraq to supplement the AIM-9G normally carried. Flying as part of a coalition package, with enemy radars, SAM sites and AAA batteries ranged against them, several Buccaneer aircrew later reflected that this was the Red Flag scenario 'for real'. Further successful attacks followed, although mid-February was marked by periods of cloud cover, which obscured the target area and caused some Pave Spike missions to be abandoned.

Desert Sky Pirates

Having spent much of late 1990 practising overland 'spiking', the call for Lossiemouth to send Buccaneers in support of Operation Granby eventually came on 23 January 1991, by which time the Iraqi fighter force had been neutralised, so allowing the use of medium-level daylight tactics. Planned sorties totalled 250, of which 226 were flown. These broke down as 32 training (most between 28 January and 5 February), 44 interdiction (mostly against bridges) and 150 offensive counter-air (against airfields).

Above left: A Buccaneer is prepared for Gulf duty in a HAS at Lossiemouth. The modifications were relatively minor and swiftly achieved, including the application of ARTF (Alkali Removable Temporary Finish) 'desert pink' paint. This aircraft is in typical 'Gulf fit', at least for initial operations, with ECM pod, slipper tank, Pave Spike and AIM-9L.

Above: One of the first batch of Buccaneers to be dispatched to the Gulf is seen on arrival at Muharraq, Bahrain, on 28 January.

Far left: The Buccaneer's base at Muharraq occupied a corner of what was also Bahrain's international airport. The RAF ground crew had the luxury of being able to use Gulf Air's hangar for maintenance work.

Below: Two Buccaneers line up with a pair of 'Snoopy Airways' Tornados to launch on the Buccaneer's first operational sortie on 2 February 1991. A total of 169 Tornado-dropped LGBs was guided by the Buccaneer/Pave Spike combination and involved Tornados from both Muharraq and Dhahran.

XV352 refuels from a Victor during a late-war mission, clutching a CPU-123 bomb to its port outer pylon (replacing a Sidewinder). The bomb is marked with an obscure message inspired by the adult comic Viz (as were many British Gulf War nose arts and bomb messages). Buccaneers delivered 48 LGBs between 21 February and 27 February, the best-known being the two weapons which hit a parked An-12 and captured C-130 at Shayka Mayhar airfield. Buccaneers initially arrived in the Gulf uncoded, receiving a single letter at Muharraq. The codes of the first six aircraft spelled the name 'PIRATE'.

Far right: XX889/T departs Bahrain on a mission, armed with an AIM-9L. The Pave Spike and ALQ-101 pods were given an ARTF paint coat at the same time as the aircraft, but the weapons were left in their original state. The aircraft soon acquired a characteristic soot stain along the rear fuselage aft of the jetpipes.

On 21 February, with superiority established, agreement was given for the Buccaneers to dispense with self-defence Sidewinders and load up one or two 1,000-lb Paveway II LGBs on the underwing stations (no. 2, starboard inner and no. 3, port outer). The first such mission represented the first time an RAF Buccaneer had ever dropped a bomb in anger. On 27 February, on the latter part of a mission in which two aircraft had successfully 'spiked' for Dhahran Tornados, the Buccaneers attacked a second target – the Iraqi airfield at Shayka Mayhar. Each Buccaneer used its Pave Spike to designate a target – Iraqi transport aircraft – and then released its bombs, in a 45° dive, into the 'laser basket'. The result was one An-12 destroyed and a captured Kuwaiti Hercules severely damaged.

It was the Buccaneers' final Gulf mission. The 12 aircraft and 18 crews had flown 250 sorties (including a few which aborted after launch, due to weather), without losing a single sortie to unserviceability. As well as guiding 169 LGBs from other bombers, the Buccaneers dropped 48 of their own. All this had been accomplished without loss, and the two Buccaneer 'spares', ready and painted in desert pink at Lossiemouth, were never required in the Gulf.

Above: Four Gulf veterans formate on the Tristar tanker during the non-stop journey back from Muharraq to Lossiemouth, undertaken on 17 March 1991.

Right: Ironically, it was XV332, the only aircraft to receive full Gulf mods not to go to war, which represented the Buccaneer in the Gulf War flypast over London.

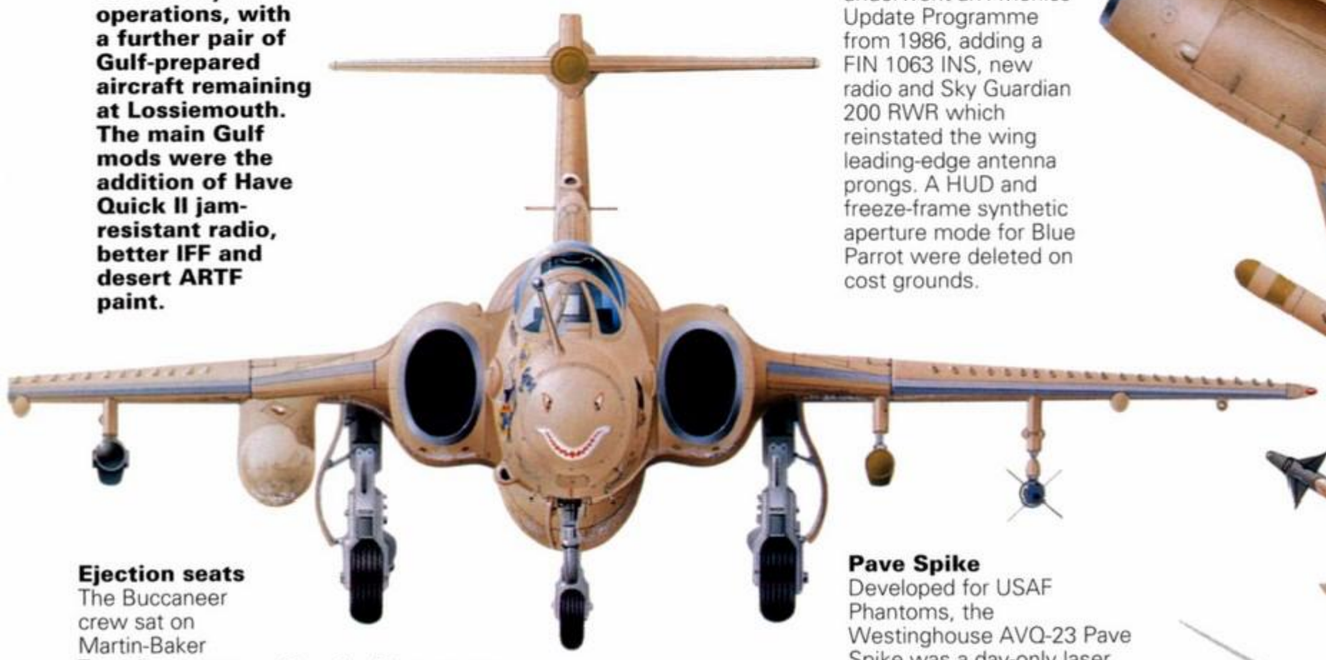
Return to Lossiemouth II

This, though, proved to be the swansong for the Buccaneer. On 17 March 1991 the 12 aircraft flew the 4,000-mile (6437-km) stage back to the UK, refuelling three times en route from RAF Tristar tankers. Their welcome at Lossiemouth was rapturous, with thousands of people turning out in the rain to mark the event. Many of the aircraft had their Desert Storm artwork and pink paint scheme removed in the days that followed, which in a way was unfortunate, since the artwork (applied on six of the aircraft by ground crewman Ken Letham) was of a high standard, and far more suited to 'family viewing' than the *Viz* characters seen on some of the Coltishall Jaguars returning from the Gulf.

Back at Lossiemouth, the Wing began to contract. With the reducing need for new aircrew, No. 237 OCU disbanded on 1 October 1991, its Buccaneers and Hunters being distributed to the two remaining squadrons. No. 12 followed on 30 September 1993 and became a Tornado GR.Mk 1 maritime squadron the following day, by the simple expedient of renumbering No. 27 Squadron. Anticipating this event, Lossiemouth engineers designated Buccaneers as 'long term' and 'short term', the former being the examples best suited to continuing operations until No. 208's retirement of the type. No. 208 had an establishment of 12 Buccaneers right through to the end, although the 'fox' markings of No. 12 remained on some of its aircraft. There was something of a scare in October 1993, when an aircraft suffered an airbrake failure in the circuit. This potentially serious problem, coming just six months before the planned retirement, raised the very real possibility of

Buccaneer S.Mk 2B
Granby detachment
Muharraq, Bahrain

Two batches of six Buccaneers were deployed for Granby operations, with a further pair of Gulf-prepared aircraft remaining at Lossiemouth. The main Gulf mods were the addition of Have Quick II jam-resistant radio, better IFF and desert ARTF paint.



Ejection seats
The Buccaneer crew sat on Martin-Baker Type 6 zero-zero seats, the pilot's being designated the MSB1 and the navigator's the MSB2. The navigator's seat was subtly modified to give greater knee clearance after the Martel display screen was added in a central console.

Granby Buccaneers
The first six Buccaneers deployed to Muharraq between 26 and 28 January 1991 were XW530, XW533, XW547, XX889, XX892 and XX899. Following on 7/8 February were XV352, XV863, XX885, XX894, XX895 and XX901. Two further aircraft, XV332 and XX893, were prepared but remained at Lossiemouth.

AUP
Forty-two Buccaneers underwent an Avionics Update Programme from 1986, adding a FIN 1063 INS, new radio and Sky Guardian 200 RWR which reinstated the wing leading-edge antenna prongs. A HUD and freeze-frame synthetic aperture mode for Blue Parrot were deleted on cost grounds.

Pave Spike
Developed for USAF Phantoms, the Westinghouse AVQ-23 Pave Spike was a day-only laser designator. It was 12 ft (3.66 m) long, of 10 in (25.4 cm) diameter and weighed 425 lb (193 kg). Contained in a rolling/gimballed nose section were the electro-optical systems which included a TV camera and laser designator/rangefinder. TV imagery was displayed on a cockpit screen, and the navigator had a small controller for slewing the graticule on to the DMPI (designated mean point of impact). A tracker system kept the TV camera staring at the DMPI, so that, when commanded by the navigator, the boresighted 1.064 µm laser fired directly at the DMPI.

Wing modifications
Following the February 1980 crash which grounded the Buccaneer fleet, severe damage was discovered in the inner wings of most aircraft, probably caused by the different loads imposed by the more pointed wingtips introduced by the S.Mk 2. A wing modification programme ensued for the least damaged aircraft, while others were put into storage. It became commonplace for aircraft to fly with the wing-fold inspection hatches left off to allow easy ground inspection.

Laser-guided bomb
Until delivery in the 1990s of the GBU-24 Paveway III, the UK's standard laser-guided bomb was the CPU-123 Paveway II, developed jointly by Texas Instruments, the RAE and Portsmouth Aviation. The CPU-123 is based on the 1,000-lb (454-kg) Mks 13 (RWA 4 explosive filling), 18 (Torpex filling) or 20 (runway-cratering) bombs. The pop-out fin-kit is designated Type 120 and extends the gliding distance of the bomb. The Paveway II guidance kit, bolted on to the front of the bomb, consists of a gimballed laser seeker, guidance computer and four control fins.

Sidewinder
Throughout its career the Buccaneer has carried all three generations of Sidewinder, beginning with the tailchase AIM-9B, followed by the improved AIM-9G and finally the all-aspect AIM-9L. The latter was the standard defensive armament during the final years of the Buccaneer's active service, and was carried during early desert ops. It was subsequently removed in favour of an LGB. Dimensions of the 'Nine Lima' are: length 9 ft 5 in (2.87 m), diameter 5 in (12.7 cm), wing span 2 ft 1 in (0.64 m) and launch weight 192 lb (87 kg).

Debates concerning the Buccaneer's planned retirement dragged on for some time, but with the major realignment of Britain's strike/attack forces which followed Desert Storm and, more importantly, the end of the Cold War, the days of the Buccaneer were numbered. The withdrawal of four squadrons of Tornados from Germany created an immediate surfeit of these aircraft and the replacement of the anti-ship Buccaneers by Tornado GR.Mk 1Bs was an inevitable decision. Although the nav/attack system of the Tornado is generally superior to that of the Buccaneer, there are notable disadvantages (lower range, reduced radar range in overwater operations, initial limitations on Sea Eagle firing to reversionary mode only, and the ability to only carry two of the missiles as a meaningful warload as opposed to four).

the date being brought forward, but modifications proved successful and operations continued.

No. 208 took part in a number of deployments and exercises in its final Buccaneer year, visiting St Mawgan for operations in the southwestern approaches, deploying to Norway and Denmark, and visiting Cyprus for training over the Mediterranean. The final deployment was to Gibraltar from 18 to 28 February 1994, to exercise with the Royal Navy on a Principal Weapons Officer (PWO) course. On 12 June 1993, Squadron Leader Rick Phillips had led 16 Buccaneers over central London for the Queen's Birthday flypast, in what was – at least from the public perception – a farewell to the type. Operating from RAF Manston, the diamond 16 'Blackburn Formation' (its radio callsign) comprised aircraft and crews from both Nos 12 and 208 Squadrons. Never again would the RAF be able to put as many Buccaneers in the air together.

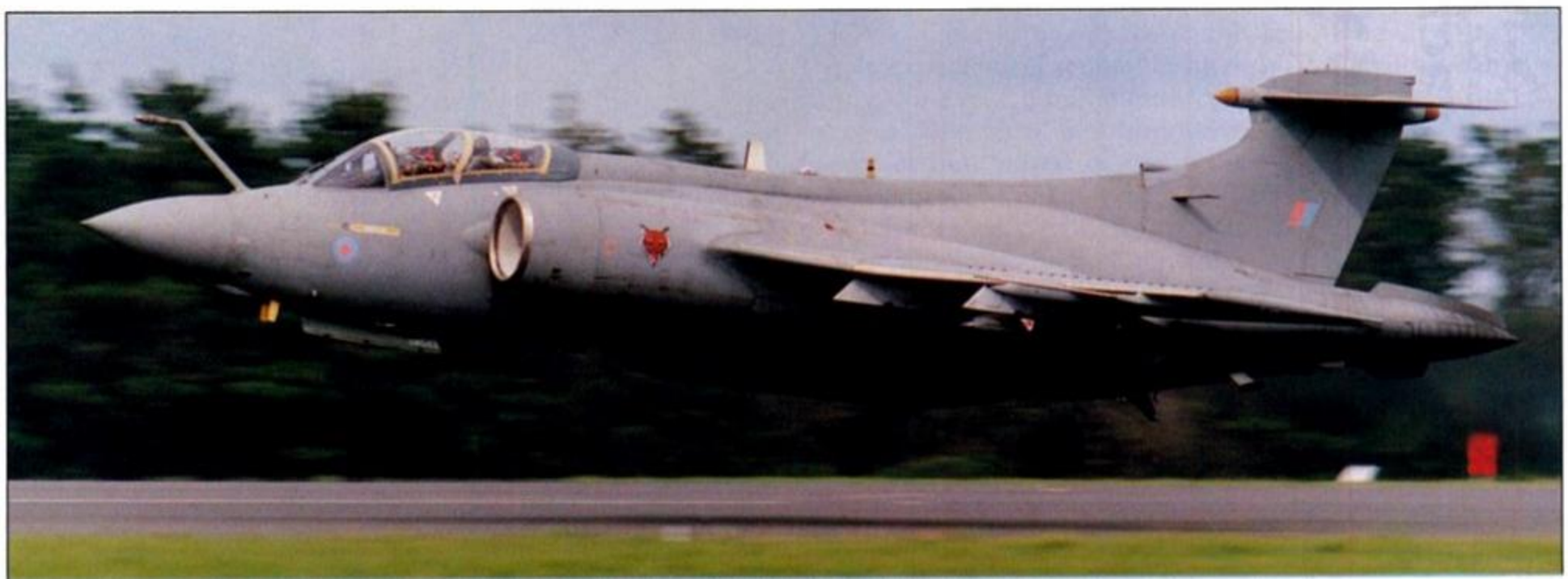
The Buccaneer was clearly not going to go out with a whimper. To mark No. 208's retirement of the type on 31 March 1994, the squadron's boss, Wing Commander Nigel Huckins, had several of his aircraft repainted in the marking of RAF squadrons which had operated the Buccaneer over the years. XV352 received the markings of No. 237 OCU, XV359 of No. 12 Squadron (which, in fact, had never been repainted since the squadron's re-equipment), XV361 of No. 15 Squadron, XW527 of No. 16 Squadron, and XX901 of No. 216 Squadron. Perhaps the crowning glory was XX894, which received the full treatment to emerge in February 1994 in overall extra dark sea grey with the Royal Navy markings of No. 809 Squadron and codes 'R/020'. Only a pedant would note that this particular aircraft had never flown with the FAA and had a bomb door tank.

The last production Buccaneer, XZ432, had come off the Brough line in October 1977, while a number of ex-FAA aircraft (of the XV332-XV361 and XV863-XV869 batches) remained in front-line use at Lossiemouth until the type's retirement. Airframe ages thus ranged from 17 to 27 years, and hours from 3,450 to 5,150. Fleet leader was XV168, which reached its Fatigue Index (FI) limit at 6,200 hours and had been put on permanent display at Brough after its final flight on 15 October 1993.

Wing Commander Huckins led a nine-ship Buccaneer formation over Lossiemouth on 26 March 1994 as the highlight of a 'farewell weekend' attended by hundreds of Buccaneer air and ground crews and their families, after which the individual aircraft 'attacked' the airfield at low level. Taxiing back to the dispersal, the nine Buccaneers simultaneously folded their wings and shut down their engines.

The end

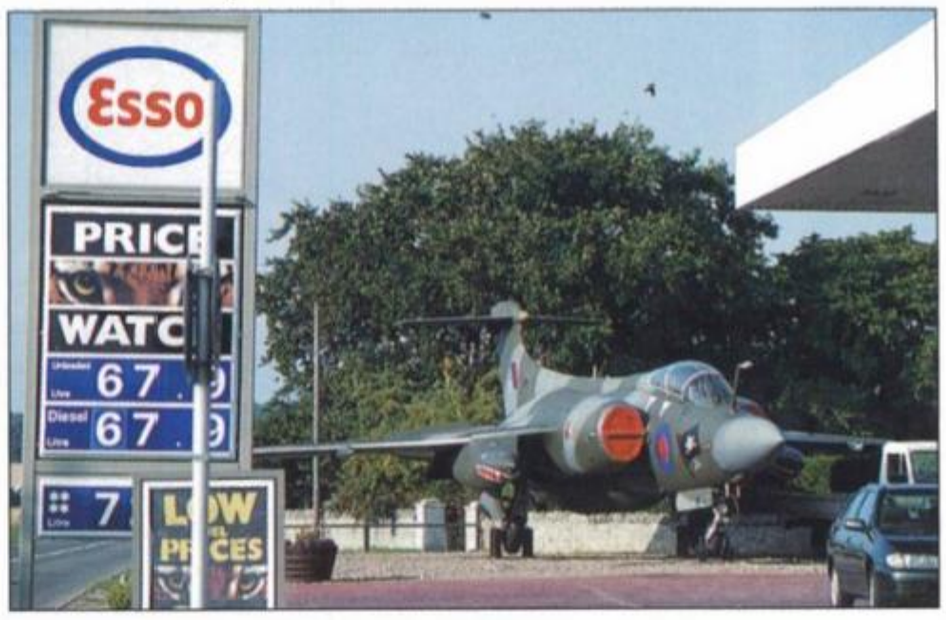
In truth, this was the symbolic end for the Buccaneers, but limited operations continued until the squadron down-declared to NATO on 31 March 1994. On that date, the No. 208 Squadron standard passed to a Hawk squadron at RAF Valley, flying in a very different role. The demise of the Buccaneer also signalled the end of the Hunter in RAF service, and examples of both types quickly and quietly left Lossiemouth, to be distributed to museums, other RAF establishments, fire dumps, for BDR and to scrapyards. No RAF Buccaneer was ever to fly again. The three DRA (ex-RAE) aircraft – XW986-XW988 – continued flying for a while longer, but all were withdrawn from active use by February 1995. XW987 and XW988 were sold to South African collector Mike Beachyhead. The 1 April 1997 departure from St Mawgan of XW987, by then civil registered as ZU-BCR, surely marked the last flight of a Buccaneer in British airspace. **Denis J. Calvert**



A typical 'Bucc' take-off – the gear on XW543 completes its retraction sequence while the aircraft is still just feet off the runway. Buccaneers usually took off 'unblown' from land, accepting a higher take-off speed and longer run as a trade-off for being able to use the full thrust of the Speys. The mid-grey scheme was adopted late in the aircraft's career, offering good protection against sky or sea.

Now populated by Tornados and Jaguars, RAF Lossiemouth still holds the Buccaneer dear to its heart. Pride of place on the gate is given to Granby warrior XV863 **Sea Witch.**

The Buccaneer is also fondly remembered at its 'second' home – RAF Honington. The gate-guard there is XK526, the first S.Mk 2 conversion, placed on display in 1987.



Above: Front-line service for the Buccaneer ended on 31 March 1994, when Tornados took over the anti-ship role. Many 'Bucc' veterans lamented the aircraft's passing, considering it to be a better tool in this role than its replacement.

Left: Many Buccaneers have been preserved for posterity in the UK. XW530 uniquely acts as gate-guard to a service station on the road from Elgin to Lossiemouth.

Left: One of the best preserved examples is XX901, owned by the Buccaneer Aircrew Association and displayed at Elvington.

Below: In 1998 the only flying Buccaneers were the two ex-DERA examples owned by Mike Beachyhead in South Africa, ZU-AVI (below left, ex-XW988) and ZU-BCR (ex-XW987).

Buccaneer Operators

Production of the Buccaneer totalled 209 airframes, 60 of which were built as Gyron Junior-powered NA.39s or S.Mk 1s, the remaining 149 as Spey-powered S.Mk 2s or S.Mk 50s. Production of series machines ran from January 1962 to October 1977. By variant the production breakdown consisted of: NA.39 – 20, S.Mk 1 – 40, S.Mk 2 (Navy) – 84, S.Mk 2B (RAF) – 45, S.Mk 2B (RAE/RRE) – 4 and S.Mk 50 – 16. Ten further S.Mk 2s were on order for the Navy but were cancelled, while two of the NA.39 batch were converted to serve as S.Mk 2 prototypes. Serials are listed under the relevant headings. David Donald and Denis J. Calvert

Right: Having started its naval career partnering the Sea Vixen fighter, the Buccaneer ended it alongside Phantoms.

Royal Navy

The Navy ordered a total of 50 S.Mk 1 aircraft for the Fleet Air Arm in 1958, these following on from the development batch. In the event, only 40 S.Mk 1s were completed as such, delivered between January 1962 and February 1964. Serials were XN922 to XN935, and XN948 to XN973. The final 10 airframes covered by the order (XN974 to XN983) were completed as the first batch of S.Mk 2s.

An announcement of the Navy S.Mk 2 order was made on 8 January 1962, and a total of 94 aircraft was ordered in several batches, although only 84 were delivered. Serials were XN974 to XN983, XT269 to XT288, XV152 to XV168, XV332 to XV361, and XV863 to XV869. The final batch should have contained 10 more airframes (XV870 to XV879) but these were cancelled when partially built following the fire on *Victorious*.

Front-line Navy service began when No. 801 Squadron stood up on 17 July 1962, and ended when No. 809 Squadron stood down on 15 December 1978.

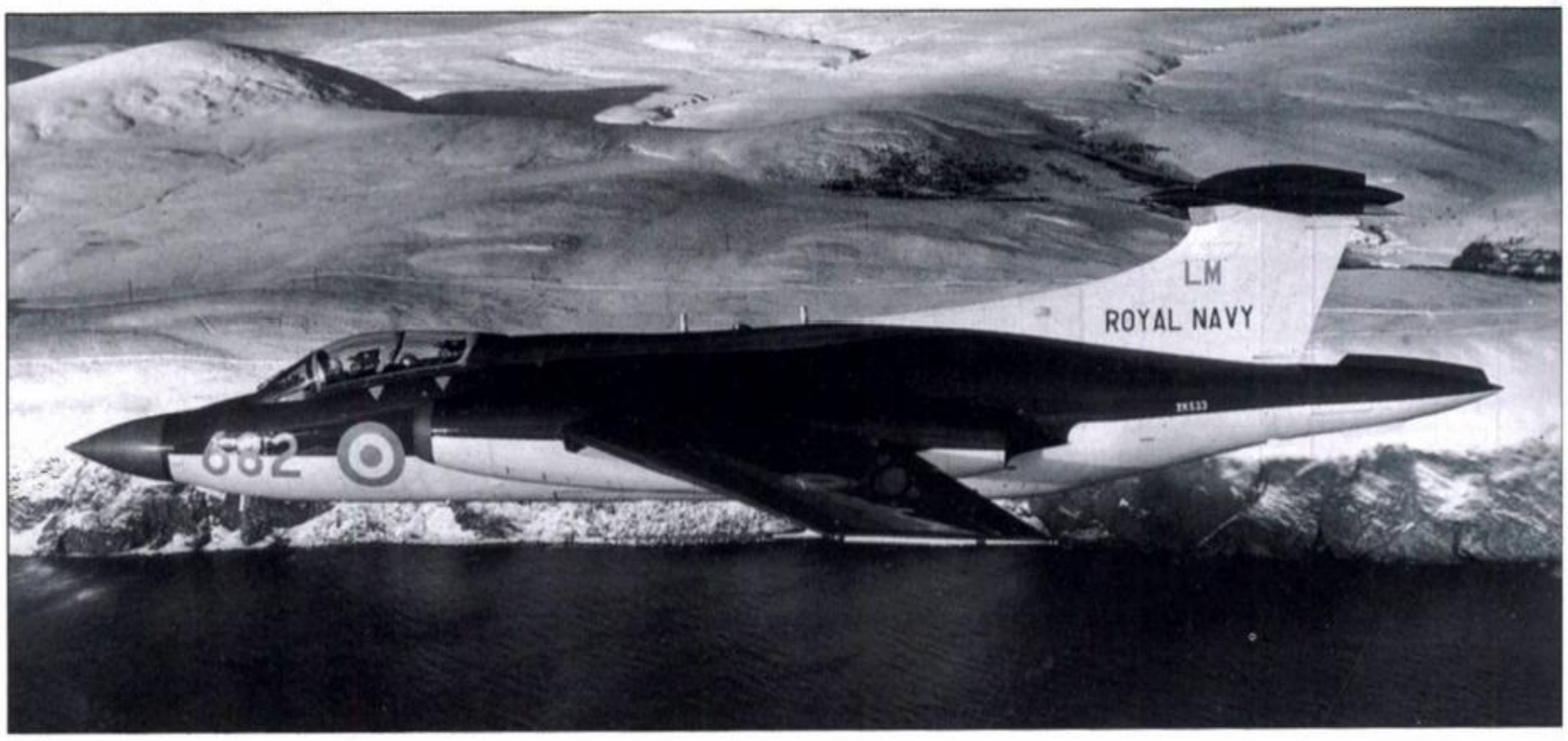
No. 700Z Flight

Aircrew for the Buccaneer Intensive Flying Trials Unit began assembling at RNAS Lossiemouth in January 1961. The flight had not officially formed, and no aircraft were assigned, so the aircrew got airborne in whatever they could borrow from the resident squadrons or the station flight. The emphasis was placed on light twin experience, for which the Seahawks of No. 738 Sqn were heavily utilised. No. 700Z Flight was officially commissioned on 7 March 1961, with Lieutenant Commander A. J. Leahy, MBE, DSC as its commanding officer. With no aircraft, operations continued as before.

The first aircraft allocated to 700Z did not arrive until 2 May and was a Meteor T.Mk 7 WS116, followed by a second Meteor (WS104) on 10 May. A week later, on 17 May, the first of an eventual four Hunter T.Mk 8s was assigned to the flight, allowing uninterrupted training to be undertaken. Finally, on 3 August, the first two Buccaneer S.Mk 1s (XK531 and XK532) were delivered, followed in November by two more, and then a further pair in early 1962 to bring 700Z's maximum complement up to six aircraft.

From the moment it received its first Buccaneers, 700Z Flight eagerly embarked on its role as the Intensive Flying Trials Unit, testing every facet of the new aircraft while evolving tactics for its use. This task was increased in December 1961 when the first weapons systems were installed in two aircraft. IFT work was undertaken throughout the first half of 1962, and by mid-summer the Buccaneer was cleared for service use. Accordingly, No. 801 Squadron was commissioned on 17 July around a nucleus provided by 700Z. The IFT work continued until the end of the year, punctuated by an appearance at the Farnborough air show in September, during which 700Z put up a four-ship of Buccaneers. To cater for this event, 700Z borrowed five aircraft from No. 801. The IFTU's work was over by the end of the year, and the unit's last flying day was on 20 December 1962, by which time 700Z had flown 1258.30 hours in the Buccaneer for the loss of one aircraft (XK535 LM/634 on 18 August 1962). When the personnel returned after their Christmas leave, 700Z Flight had become the nucleus for No. 809 Squadron, which officially formed on 15 January 1963.

700Z's S.Mk 1s were coded LM/680-689. The first aircraft were from the pre-production batch, followed by a few early production machines.



No. 700B Flight

It is common Royal Navy practice to establish a small unit to undertake trials and evaluation work on new types entering service, usually designated as flights with a 700 number (No. 700 Squadron ceased to exist as a cohesive fleet requirements and trials unit in 1961 but the work was continued by discrete flights). No. 700B Flight was formed at Lossiemouth on 7 April 1965 as the Buccaneer S.Mk 2 Intensive Flying Trials Unit, with Commander N. J. P. Mills at the helm, the unit being commissioned two days later. Flying had started unofficially on 31 March, using four Buccaneer Mk 2s (XN977, XN978, XN981 and XN982) and a single Hunter T.Mk 8 (XE664, replaced in June by XF978). By June, 700B had seven S.Mk 2s assigned.

With much of the basic new-type IFT work having already been performed for the S.Mk 1, 700B had a much shorter existence than its predecessor, and most of its work was concerned with weapons-dropping and refuelling trials. Bombing was usually conducted on Tain range close to Lossiemouth, or at West Freugh. On 7 May a 700B aircraft initiated the S.Mk 2's refuelling trials by receiving from a No. 803 Squadron Scimitar, while trials of the S.Mk 2 as a tanker began on 27 July. The previous day 700B had launched its first 2-in rocket projectiles and Bullpup missiles, the latter at Aberporth. To cap a successful July, the unit made its first deck landing on 29 July, landing aboard *Centaur*. IFT work for the Buccaneer S.Mk 2B came to an end on 30 September 1965, on which day No. 700B Flight disbanded to form the nucleus of the first S.Mk 2 unit: No. 801 Squadron.

700B Flight (codes LM/725-734) was only in existence briefly, but its aircraft were much publicised. The unit adopted a winged 'B' on the fin as its badge.

No. 736 Squadron

On 29 March 1965, No. 809 Squadron at Lossiemouth was renumbered as No. 736 Squadron, under the command of Lieutenant Commander W. H. C. Watson. The role of the unit was to train pilots and observers for the front-line Buccaneer force, its alternative title being the Jet Strike Training Squadron. Regular Deck Landing Practice (DLP) detachments were made to provide carrier qualifications. At the time of its formation, No. 736 had seven S.Mk 1s (XK534, XN924, XN950, XN957, XN961, XN965 and XN967) and a single Hunter T.Mk 8 (WV322) allocated. This inventory was to rise to a maximum of eight S.Mk 1s and 12 S.Mk 2s in 1970. The early period of 736's Buccaneer career was marred by the loss of the CO in a crash on 25 June 1965.

On 9 May 1966, the unit's first S.Mk 2 (XT284) arrived at Lossiemouth and the number steadily rose thereafter. In September 1967 the squadron performed a 12-aircraft flypast before the Queen at Clydebank. Both S.Mk 1s and 2s were operated together until December 1970, when two crashes of S.Mk 1s were followed by a grounding of the variant and its withdrawal from service. The last Mk 1 left for the NASU in January 1971. Throughout its history, 736 lost three Mk 1s and four Mk 2s.

No. 736 Squadron used three code ranges – LM/630-637, LM/640-644 and LM/650-657 – and operated both S.Mk 2s (above) and S.Mk 1s (right) for training work. The S.Mk 1 was usually used for initial conversion.

In late March 1967 the grounded tanker *Torrey Canyon* provided 736's personnel with some light relief when they (along with No. 800 Sqn) were tasked to bomb the stricken vessel in an attempt to ignite and destroy its cargo of crude oil. In 1969 No. 736 picked up the task of training RAF Buccaneer crews, the first course of which began Buccaneer flying in June after a familiarisation course in Hunters. No. 1 RAF Course left for Honington in September. In the early 1970s the Royal Navy usage of the Buccaneer wound down, while that of the

RAF stepped up. Accordingly, the training function for both services was handed over to the RAF's No. 237 OCU, although carrier qualifications were handled by the last remaining naval squadron, No. 809. No. 736 Squadron's last flying day was 22 February 1972, and on 25 February the unit disbanded.

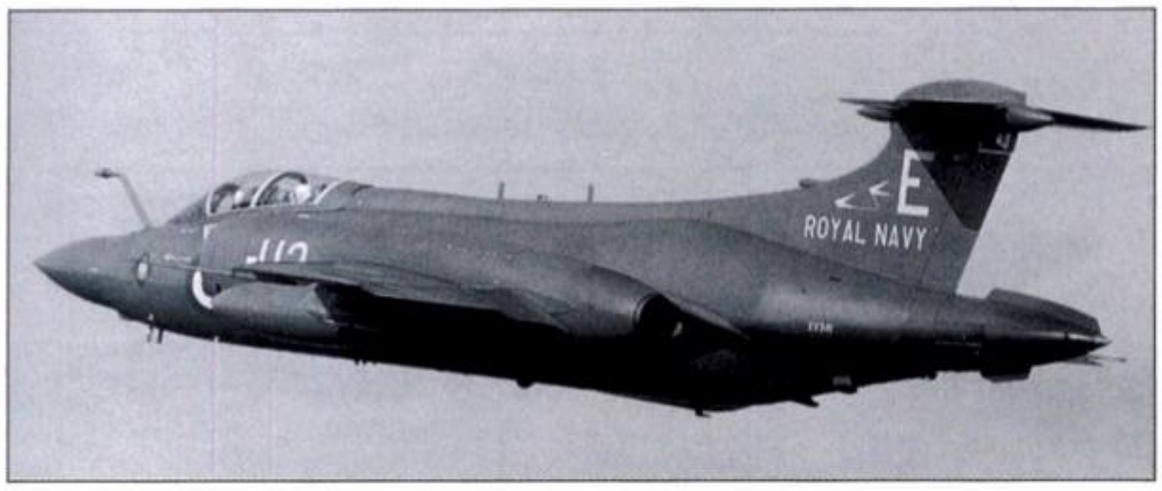
No. 800 Squadron

Until 25 February 1964, No. 800 Squadron had been a fleet Scimitar unit, assigned to HMS *Ark Royal*. After a brief interlude, the squadron was recommissioned on 18 March 1964 as the second front-line Buccaneer S.Mk 1 squadron, with Lieutenant Commander J. C. Mather as commanding officer. The initial complement was six S.Mk 1s and a single Hunter T.Mk 8. Between September 1964 and August 1966, the associated No. 800B Flight was operational at Lossiemouth, using four Scimitar F.Mk 1s on refuelling duties. The squadron spent most of the remainder of 1964 working up on its new aircraft, including the delivery of nuclear 'shapes' from August. On 2 December it embarked in *Eagle* for its maiden cruise and the following May left for the first of several Far East cruises. In December 1965 *Eagle* and No. 800 were diverted to man the Beira patrol off the Mozambique coast, enforcing the blockade against Rhodesia. The squadron remained with HMS *Eagle*

throughout its Buccaneer career. On 14 August 1966 the squadron disembarked to Yeovilton and Lossiemouth to end its period of active service with the S.Mk 1.

In early September 1966 the unit's first S.Mk 2 (XV156) arrived, and after maintenance training the squadron flew its first sortie in the new variant on 27

No. 800 Squadron made one major cruise aboard* Eagle *with the S.Mk 1. This included operations off Aden and on the Beira patrol.



September. On 10 February 1967 the squadron had worked up to operational standard, and was rededicated as an S.Mk 2 unit, initially with eight aircraft, although this figure would later rise to 12. The following month No. 800 was given the unusual task of flying bombing missions against the grounded tanker *Torrey Canyon*. Three aircraft flew the squadron's first strike on 28 March, each dropping six 1,000-lb bombs. The following day saw No. 800 'Buccs' mount eight sorties, using Brawdy as a base, while two days six more attacks were made. Another Far East cruise followed, during which No. 800 was on alert while the Malayan Federation talks were being held, in November 1967. A series of home waters/Mediterranean cruises ensued, followed by one last visit to the Far East in 1971. A month after its return, No. 800 Squadron disbanded at Lossiemouth on 23 February 1972. It was to be eight years before the squadron was reformed, with Sea Harrier FRS.Mk 1s.

Left: No. 800 survived into the 1970s, still wearing* Eagle*'s tailcode. The squadron badge was presented on the nose. 800's S.Mk 2s served in the all-over dark grey scheme.

Below: An 800 S.Mk 2 smartly tucks up its gear, launching from Luqa. The squadron spent much of its five years with the Mk 2 on cruises in European or Mediterranean waters.

No. 800 Squadron cruises

From	to	carrier	variant	area
2.12.64	21.5.65	*Eagle*	S.Mk 1	Home/Med
25.8.65	14.8.66	*Eagle*	S.Mk 1	Far East (four shore calls at Changi)
26.6.67	18.7.67	*Eagle*	S.Mk 2	Home/Med
15.8.67	18.6.68	*Eagle*	S.Mk 2	Far East (two shore calls at Changi, one at RAAF Pearce)
28.8.68	2.10.68	*Eagle*	S.Mk 2	Home/Med
10.4.69	28.4.69	*Eagle*	S.Mk 2	Home/Med
23.5.69	7.6.69	*Eagle*	S.Mk 2	Home/Med
13.6.69	18.7.69	*Eagle*	S.Mk 2	Home/Med
4.9.69	4.12.69	*Eagle*	S.Mk 2	Home/Med (shore calls at North Front and Luqa)
10.1.70	23.3.70	*Eagle*	S.Mk 2	Home/Med
2.10.70	9.12.70	*Eagle*	S.Mk 2	Home/Med
17.1.71	31.3.71	*Eagle*	S.Mk 2	Home/Med (shore call at Luqa)
26.5.71	23.1.72	*Eagle*	S.Mk 2	Far East (two shore calls at Tengah, one at Kai Tak)

No. 801 Squadron

Formed round a nucleus of personnel from No. 700Z Flight, No. 801 Squadron was chosen to be the Royal Navy's first front-line Buccaneer unit. It was recommissioned on 17 July 1962 with Lieutenant Commander E. R. Anson in command, but it was not until 26 July that it received its first aircraft (XN965). By the end of August the strength had reached five aircraft (subsequently loaned to 700Z Flt the following month) and had reached the maximum strength of 10 by August 1963. During its time with the S.Mk 1, No. 801 lost three aircraft.

Following an intense work-up period, the squadron deployed afloat for the Buccaneer's first cruise in February/March 1963, aboard HMS *Ark Royal*. This was a shakedown cruise to the Mediterranean prior to the squadron's only major cruise with S.Mk 1s, a voyage in HMS *Victorious* which took the unit away from Lossiemouth for nearly two years. During this long sojourn, the squadron disembarked for a fortnight in February 1964 to Embakasi (Nairobi). This was a contingency measure during the restoration of law and order by British forces in Tanganyika. The Buccaneers were not called upon during the crisis. When the squadron finally returned to Lossiemouth on 22 July 1965, the days of its S.Mk 1 operations had virtually ended, as the unit disbanded five days later, on 27 July.

Under the command of Lieutenant Commander J. F. de Winton, No. 801 Squadron stood up again as the Navy's first front-line Buccaneer S.Mk 2 squadron on 7 October 1965, and was formally commissioned as such on 14 October, at which time the squadron had seven aircraft (XN979, XN980, XN981, XN982, XT269, XT270 and XT271). The nucleus for the 'new' squadron was provided by the recently disbanded No. 700B Flight. During its time with the Mk 2, the squadron lost four aircraft.

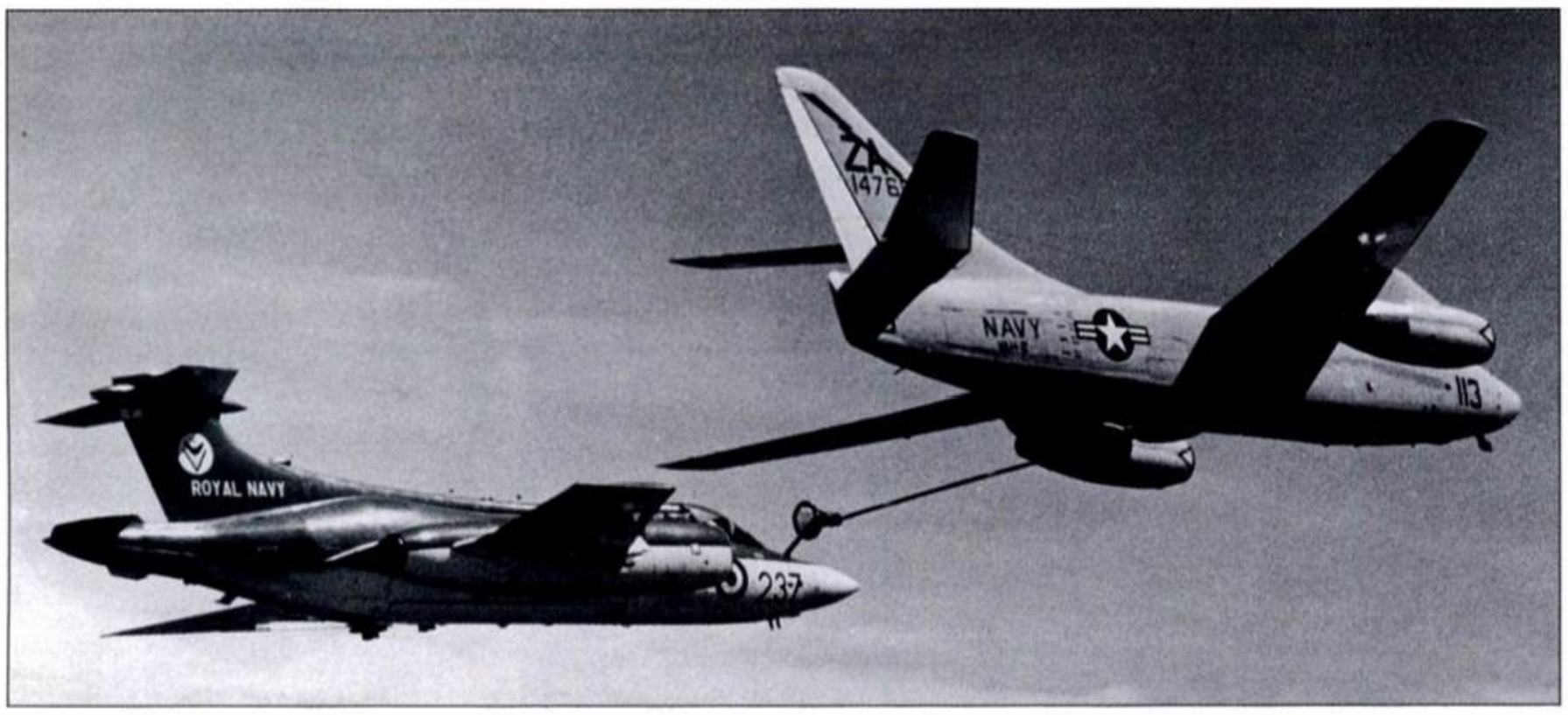
Bringing the new type into full service was the major task presented to No. 801 during the remainder of 1966 and early 1967, the first work-up cruise being accomplished in *Victorious*. The efforts of the squadron brought it the prestigious Boyd Trophy in 1967. A major Far East cruise followed.

In November 1967 *Victorious* suffered a devastating fire which put an end to the carrier's operational life. The crew and squadrons were transferred to HMS *Hermes*, in which No. 801 embarked for a single Far East cruise and several shorter trips. The last of these saw No. 801 return to Lossiemouth on 17 June 1970. On 18 July the squadron undertook its last Buccaneer flight, and three days later disbanded. It was reformed 11 years later as a Sea Harrier squadron.

This 801 Sqn S.Mk 1 is seen before its first cruise to the Far East and Africa. Initially, the squadron operated a few all-white aircraft.

No. 801 Squadron cruises

From	to	carrier	variant	area
19.2.63	14.3.63	*Ark Royal*	S.Mk 1	Home/Med
14.8.63	22.7.65	*Victorious*	S.Mk 1	Far East, then Indian Ocean, return to Far East (five shore calls at Tengah, two at Kai Tak, one at Embakasi, one at Cubi Point and three at Changi)
14.5.66	8.6.66	*Victorious*	S.Mk 2	Home/Med
8.7.66	13.6.67	*Victorious*	S.Mk 2	Far East (three shore calls at Changi)
31.5.68	20.6.68	*Hermes*	S.Mk 2	Home/Med
9.7.68	30.3.69	*Hermes*	S.Mk 2	Far East (two shore calls at Changi)
25.9.69	27.10.69	*Hermes*	S.Mk 2	Home/Med
14.11.69	4.12.69	*Hermes*	S.Mk 2	Home/Med
19.1.70	17.6.70	*Hermes*	S.Mk 2	Home/Med (two shore calls at Luqa)



801 remained assigned to* Victorious *until the ship's demise in late 1967, when the squadron transferred for five cruises aboard* Hermes. *Here an S.Mk 2 is seen refuelling from a VAH-2 KA-3B Skywarrior.

No. 803 Squadron

Previously a Scimitar operator, No. 803 Squadron was formed at Lossiemouth on 3 July 1967 as the Buccaneer Headquarters Squadron, with Lieutenant Commander M. J. A. Hornblower as CO. It was initially allocated two S.Mk 1s (XN959 and XN971) which were joined by XN963 and XN964 by September. Crews began converting to the S.Mk 2 in October 1967, the first of four Mk 2s (XV165) arriving with the unit on 24 January 1968. The last pair of S.Mk 1s had left the unit by the end of July 1968.

In its role of Headquarters Squadron, No. 803 was involved mostly in ongoing trials of new weapons and avionics. These began with trials of air-to-air TACAN for refuelling rendezvous, and bomb hang-up tests. Varying weapons tests occupied the squadron until its final disbandment, two of the last tasks being testing of Lepus flares and the dropping of the '600-lb shape', a euphemism for the new laydown WE177 nuclear weapon. No. 803's finest moment came in Exercise Bobbin Plus, which involved the rapid deployment of four S.Mk 2s from Lossiemouth to the Far East. Leaving Scotland on 18 August 1968, the Buccaneers and two Victor tankers from No. 55 Squadron routed via Nicosia, Masirah and Gan to arrive in Malaya after 17 hours 55 minutes flying time, accomplished over four days. While the Victors landed at Butterworth, the Buccaneers trapped aboard HMS *Hermes* sailing off the Malayan coast. In the back seat of one of the aircraft was none other than the First Sea Lord.

With the Navy's Buccaneer force set to dwindle to just one squadron, the requirement for an HQ unit evaporated as the 1960s drew to a close. No. 803 Squadron was duly disbanded on 18 December 1969.

803 Squadron aircraft were somewhat camera-shy. These two photographs show XT284 with (below) and without (right) the yellow/black fin-band. The squadron badge of a hornet was worn on the intakes.

No. 809 Squadron

On 15 January 1963, the remnants of No. 700Z Flight were commissioned as No. 809 Squadron, otherwise known as the Strike Headquarters Squadron. Newly promoted Commander A. J. Leahy, MBE, DSC remained in command during the change. At the time of formation, No. 809's inventory comprised five S.Mk 1s (XK531, XK532, XK533, XK534 and XK535) and a single Hunter T.Mk 8 (WW664), although the number grew as the re-equipment effort got into full swing.

In addition to some ongoing trials work, No. 809's principal task was training pilots and observers. The first course started the day after formation. The training task was eased considerably with the arrival of a simulator in November 1963. Shortly before No. 809 was temporarily decommissioned, the unit began to train two South African crews, who arrived on 11 January 1965. Among them was Commandant Rogers, the prospective commanding officer of the SAAF Buccaneer squadron. No. 809 continued to produce high-quality Buccaneer crews until it was renumbered as No. 736 Squadron on 26 March 1965. It had lost three S.Mk 1s during its career as the Buccaneer training unit.

As befits a unit with the phoenix as its badge, No. 809 was not dormant for long, for it had been earmarked to join the front-line force with Buccaneer S.Mk 2s. The first of the new aircraft (XT278 and XT280) for the reborn squadron arrived on 3 January 1966, and by the end of the month three more (XT277, XT279 and XT281) had arrived. No. 801 Squadron assisted with the training and formation, so that by the time Lieutenant Commander L. E. Middleton officially took charge of the commissioned No. 809 on 27 January, the squadron had already made a considerable start to the process of forming a new unit.

After a successful work-up on its new aircraft, No. 809 was assigned to HMS *Hermes* for the first of two Far East cruises. During the first of these, in 1967, *Hermes* spent a period patrolling off the coast of Spain after the Spanish unilaterally imposed restrictions on aircraft landing at Gibraltar's North Front airfield. During the second cruise, in early 1968, the squadron spent some time operating in the Aden region. Between the end of February 1968 and May 1970, the squadron remained ashore, but when it did return to sea it was aboard a new carrier, HMS *Ark Royal*. No further Far East cruises were made, and operations were all conducted in Home Waters, the Mediterranean or the Atlantic. *Ark Royal* and No. 809 became regular visitors to the United States, the first such visit being made in June/July 1971, and followed by others in February 1972, June 1973, February-March 1975, March-May 1976, April-June 1978 and August 1978.

As a training unit No. 809 operated the S.Mk 1 from Lossiemouth (above). The Phoenix badge was initially worn on the intake in red.

With the winding-down of the Royal Navy's Buccaneer force from three squadrons to one, and with the disbandment of the headquarters and training units, it was decided to move No. 809's shore base to RAF Honington, from where the naval unit operated alongside the 'crab' Buccaneers of the RAF. No. 809 moved into its new base at the end of a short home waters cruise, disembarking to the Suffolk airfield on 18 October 1972. Ironically, the RAF's Buccaneers moved back to the aircraft's spiritual home at Lossiemouth in the early 1980s.

Having been established with standard S.Mk 2s, No. 809 became the recipient of fresh equipment in the course of 1973, beginning in July with the receipt of S.Mk 2Cs. Martel-capable S.Mk 2Ds followed in October 1973, and by the end of the year the standard S.Mk 2 had been phased out. Both new variants served side-by-side until the final days of the squadron.

No. 809 Squadron had soldiered on as the last remaining Fleet Air Arm Buccaneer unit since February 1972, undertaking carrier qualification training in addition to its front-line commitments. The decision to retire *Ark Royal* and its air wing meant that when the squadron disembarked from its final cruise in the 'Ark', its aircraft were flown to St Athan for disposal or reassignment to the RAF. The squadron itself was disbanded at Lee-on-Solent on 15 December 1978, along with No. 892 Sqn (Phantom FG.Mk 1s) and No. 849 Squadron 'B' Flight (Gannet AEW.Mk 3s).

Left: A No. 809 Squadron S.Mk 2 prepares to launch from* Ark Royal. *An initial S.Mk 2 work-up cruise on* Victorious *was followed by two on* Hermes *and 21 on the 'Ark'.

Above: During its last six years of existence, 809 flew from RAF Honington. This aircraft is seen at the base one month before the disbandment of the unit.

Below: In addition to its strike/attack duties, the Buccaneer was regularly employed as a tanker for extending the endurance of its 'Ark' deckmates – 892 Sqn's Phantoms.

No. 809 Squadron cruises

From	to	carrier	variant	area
14.5.66	9.6.66	*Victorious*	S.Mk 2	Home/Med
18.1.67	29.9.67	*Hermes*	S.Mk 2	Med, then Far East (shore calls at North Front, Hal Far and Changi)
4.11.67	18.2.68	*Hermes*	S.Mk 2	Home/Med
14.6.70	9.7.70	*Ark Royal*	S.Mk 2	Home/Med
6.9.70	26.9.70	*Ark Royal*	S.Mk 2	Home/Med
15.4.71	4.8.71	*Ark Royal*	S.Mk 2	Atlantic (shore call at Cecil Field)
15.9.71	8.10.71	*Ark Royal*	S.Mk 2	Home/Med
29.10.71	6.12.71	*Ark Royal*	S.Mk 2	Home/Med
19.1.72	8.3.72	*Ark Royal*	S.Mk 2	Atlantic
12.6.72	17.7.72	*Ark Royal*	S.Mk 2	Home/Med
4.9.72	18.10.72	*Ark Royal*	S.Mk 2	Home/Med
7.11.72	11.12.72	*Ark Royal*	S.Mk 2	Home/Med
9.2.73	14.3.73	*Ark Royal*	S.Mk 2	Home/Med (shore call at Luqa)
2.5.73	24.7.73	*Ark Royal*	S.Mk 2	Atlantic (shore calls at Fort Lauderdale and Cecil Field)
6.6.74	17.6.74	*Ark Royal*	S.Mk 2C/D	Home/Med
3.7.74	25.7.74	*Ark Royal*	S.Mk 2C/D	Home/Med
5.9.74	3.11.74	*Ark Royal*	S.Mk 2C/D	Home/Med (shore call at Luqa)
8.1.75	9.6.75	*Ark Royal*	S.Mk 2C/D	Atlantic (shore calls at Cecil Field and Oceana)
6.10.75	20.11.75	*Ark Royal*	S.Mk 2C/D	Home/Med
6.2.76	14.7.76	*Ark Royal*	S.Mk 2C/D	Atlantic (one shore call at Cecil Field, two at Oceana)
4.9.76	18.10.76	*Ark Royal*	S.Mk 2C/D	Home/Med
5.9.77	12.12.77	*Ark Royal*	S.Mk 2C/D	Home/Med
23.2.78	5.3.78	*Ark Royal*	S.Mk 2C/D	Home/Med
6.4.78	15.12.78	*Ark Royal*	S.Mk 2C/D	Atlantic (shore calls at Roosevelt Roads, Cecil Field and Oceana)

Royal Air Force

The RAF ordered the Buccaneer in July 1968, but, prior to receipt of its new-build aircraft, was assigned aircraft transferred from the Navy, modified to 'interim S.Mk 2B' standard. The first aircraft to be handed over was XW350, on 1 January 1969. Ex-Navy machines, of which the RAF eventually acquired 64, were used to form the first squadron, No. 12.

New-build S.Mk 2Bs for the RAF were built in three batches, serialled XW525 to XW550, XX885 to XX901 (minus XX897 for the RRE) and XZ430 to XZ432. The first of these reached the service in January 1970, new-build aircraft being allocated to RAF Germany squadrons.

Front-line RAF service began when No. 12 Sqn stood up on 1 October 1969, and ended when No. 208 stood down on 31 March 1994.

In RAF service the Buccaneer was used in both overland and overwater roles. The latter increased in importance dramatically after the Tornado became available for the overland strike mission.

No. 12 Squadron

'Shiny Twelve' disbanded as a Vulcan B.Mk 2 squadron at RAF Cottesmore on 31 December 1967, and lay dormant until it was chosen to be the RAF's first Buccaneer unit. Reformed on 1 October 1969 under Wing Commander G. G. Davies, No. 12 Squadron received its first four aircraft that day, when they arrived in formation, led by the CO. Among the first aircraft were XV155, XV157, XV347, XV348 and XV349, all to 'interim S.2B' standard. No. 12 was declared to SACLANT in the anti-shipping role, using the Martel missile as its primary armament.

In 1980, with an eye on the impending arrival in service of the Tornado, No. 12 prepared for a move north to Lossiemouth. The relocation of the main body of the squadron was preceded by the renumbering of No. 216 Squadron, already at Lossiemouth, as No. 12 Squadron's northern echelon. The Buccaneers from Honington moved to Lossiemouth on 3 November 1980, helping to make room for the new Tornado TWCU at Honington. The maritime strike role continued to be the squadron's main tasking, and from early 1988 the Sea Eagle entered the squadron's operational inventory. No. 12 supplied crews for the Granby detachment. The squadron retired the Buccaneer on 30 September 1993, reforming on the following day as a Tornado GR.Mk 1B unit. This was achieved by taking over the aircraft of No. 27 Squadron.

Above: No. 12 was the first RAF Buccaneer squadron, and used aircraft taken over from the Navy with some modifications (including an interim Martel capability). The squadron was assigned primarily to the anti-shipping role throughout its Buccaneer career.

Above: The members of this quartet of No. 12 Squadron aircraft each displays markings variations. The nearest pair has the 'xF' tailcodes, although the second aircraft has a 237 OCU badge. The furthest pair have the last-three presented on the fin, albeit in two different colours.

Above: Despite having acquired the final light grey colour scheme, this No. 12 aircraft retains its Gulf War 'Sky Pirates' markings.

Below: As well as their anti-ship role, No. 12 crews regularly practised low-level flying. It is believed that the RAF Buccaneers ostensibly had a nuclear role right to the end.

No. XV Squadron

Exactly a year after the formation of No. 12 Squadron, No. XV became the RAF's second Buccaneer unit, formed at Honington on 1 October 1970 with new-build S.Mk 2Bs. Wing Commander D. Collins was the first CO. Like No. 12, No. XV had been a V-bomber squadron (Victor B.Mk 1s) which had been dormant for some time before re-equipment with the Buccaneer. Having fully equipped, the squadron moved to its operational base at Laarbruch, West Germany, in January 1971.

The squadron deployed to Decimomannu in November 1971 for an Armament Practice Camp (APC), following which it was declared to NATO (SACEUR) in the overland attack role on 1 December 1971. The work-up then continued, leading to its declaration in both strike (i.e., nuclear) and attack roles on 31 December 1972. From this point on, No. XV Squadron maintained a permanent Quick Reaction Alert (QRA) force at Laarbruch of one (initially), then two nuclear-armed aircraft, held from 'soft' hangar accommodation until Hardened Aircraft Shelters (HAS) were constructed in 1976. The squadron had a primary overland role, of which the strike alert was a major part.

On 1 July 1983, No. XV Squadron ceased independent Buccaneer operations, and its Buccaneer element was absorbed by No. 16 Squadron, although No. XV's Wing Commander E. R. Cox took over as boss. Meanwhile, No. 15 (Designate) Squadron began its work-up on Tornado GR.Mk 1s, starting with the arrival of the first aircraft on 5 July.

Right: Ever since Lady MacRobert donated a Stirling bomber to the unit, No. XV Squadron has marked an aircraft with the family crest and the name 'MacRobert's Reply'. Here the early 1980s version (XT287) is seen near a German landmark.

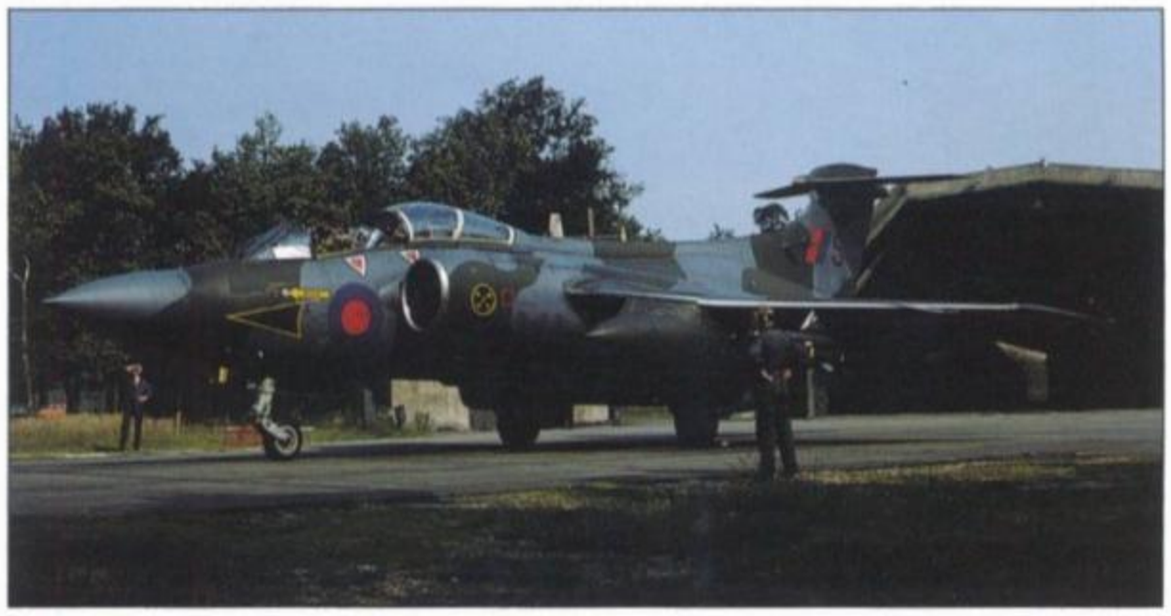
Below: RAF Germany Buccaneers occasionally practised overwater low-level operations.

No. 16 Squadron

No. 16 Squadron was a long-time resident at RAF Laarbruch, having flown the Canberra B(I).Mk 8 on strike duties since 1958. It was chosen to be RAF Germany's second Buccaneer unit, and training on the new type by No. 16 (Designate) Squadron began in October 1972, Canberra operations having ceased in June. The new Buccaneer unit officially took over the squadron number on 8 January 1973. Both RAF Germany squadrons had an identical, overland role, and both were SACEUR-assigned. Like No. XV Squadron, No. 16 worked up to its NATO declaration in attack and strike roles, with the QRA strike alert – which involved holding two armed aircraft at permanent armed readiness – being the major commitment. This alert was held by the two Laarbruch squadrons throughout their Buccaneer years, only being finally stood down some years after the general re-equipment of RAFG strike/attack squadrons with the Tornado GR.Mk 1.

No. 16 Squadron absorbed the Buccaneer operations of No. XV Sqn when the latter transitioned to the Tornado in July 1983, and continued to stand QRA until it, too, retired the Buccaneer on 29 February 1984. The Tornado-equipped No. 16 Squadron, which had received its first aircraft on 13 December 1983, took over the numberplate on 1 March 1984 to bring to an end 13 years of Buccaneer operations with RAF Germany.

No. 16 Sqn flew late-production new-build S.Mk 2Bs, operated from the characteristic RAF Germany-style hardened shelters.



No. 208 Squadron

The fourth RAF squadron was No. 208, which from 1961 to 1974 had been based in the Middle East flying Hunter FGA.Mk 9s. It was reformed at Honington under Wing Commander P.F. Rogers on 1 July 1974, although it had no assigned aircraft at the time and its aircrew initially had to 'borrow' OCU Buccaneers. Its first aircraft delivery was S.Mk 2A XT275, which was collected from the Sydenham, Belfast yard on 6 September, followed a few days later by XT278, which was collected from HoSM. Over the following 18 months, the squadron gradually replaced its S.Mk 2As with S.Mk 2Bs in a continuing programme of standardisation, building to 12 aircraft.

Initially, No. 208 was SACEUR-assigned, with an AFNORTH reinforcement role which would have taken it to Norway in time of war. The main weapon employed was the 1,000-lb HE bomb although, like all RAF Buccaneer squadrons, WE177 nuclear weapons were also available for the strike role. No. 208 became the first Buccaneer unit to deploy to Red Flag, 10 aircraft departing to Nellis in August 1977. In 1980 its assumed the Pave Spike role from No. 216 Squadron. Switched to the maritime role in 1983, No. 208 moved to Lossiemouth on 1 July to join No. 12 Squadron and acquired AR Martel as its primary weapon. In December 1986 No. 208 was chosen to introduce the BAe Sea Eagle anti-ship missile, and in 1991 supplied crews for the Gulf detachment. After disbandment of No. 237 OCU in October 1991, a Buccaneer Training Flight formed within No. 208 to continue the much-reduced training commitment, although the BTF was disbanded some time in late 1992. Upon the disbandment of No. 12 in September 1993, No. 208 absorbed aircraft and crews and soldiered on with the Buccaneer until the squadron's, and the aircraft's, final retirement on 31 March 1994. Its place at Lossiemouth was taken by No. 617 Squadron, which moved in with Tornados on 27 April 1994. The 208 numberplate was passed to the Hawk advanced/weapons training unit at Valley.

Above: Between its transition to the Buccaneer in 1974 and 1983, No. 208 Squadron served primarily in the overland role, with the Norwegian theatre its principal area of responsibility. Shown here is one of the unit's first aircraft, an S.Mk 2A.

Below: Photographed in April 1977, this aircraft is seen with temporary Arctic camouflage. The squadron subsequently went to Labrador for low-level work-up, prior to the first Buccaneer participation in Red Flag in August.

Left: From 1983 No. 208 joined No. 12 at Lossiemouth in the maritime role, bringing with it expertise in laser bombing. The tail badge is a winged eye, signifying the squadron's early history as a reconnaissance unit.

This No. 208 Squadron aircraft carries an anti-radiation Martel, which constituted the unit's first specialist weapon when it began maritime operations. It subsequently pioneered the use of Sea Eagle, although AR Martel remained in the inventory until the Buccaneer's demise in 1994.

No. 216 Squadron

The availability of No. 809 Squadron's Buccaneer S.Mk 2Cs/S.Mk 2Ds permitted the formation of the RAF's fifth and final Buccaneer squadron. Although a strategic bombing unit in World War I, No. 216 Squadron was best-known as a transport squadron, and from 1956 to 1974 had flown Comet transports from Lyneham. Intended as the second maritime, SACLANT-assigned Buccaneer squadron, No. 216 was formed on 1 July 1979 at Honington under Wing Commander Peter Sturt. The intention was that No. 216 would be the maritime Pave Spike laser designator squadron, operating alongside the Martel-equipped No. 12.

Following the grounding order in 1980, the RAF found itself with fewer aircraft available than before, and No. 216, which had not yet been declared operational, was the natural choice when it was decided to lose one Buccaneer squadron. Having moved from Honington to Lossiemouth on 4 July 1980, the squadron's complement was absorbed by No. 12 Squadron on 4 August, becoming No. 12 (North) Squadron according to some accounts. Interestingly, No. 216 did not officially disband, although it was reborn on 1 November 1984 as the RAF's TriStar operator.

No. 216 Squadron had a very brief existence as a Buccaneer operator. The intake badge consisted of an eagle carrying a bomb in its talons.

No. 237 Operational Conversion Unit

Following graduation of the No. 7 RAF Course in March 1971, the work of No. 736 Squadron at Lossiemouth was largely completed, the Royal Navy's only continuing requirement being for crews for No. 809 Squadron. The RAF's aircrew training needs were still expanding, though, and a full RAF Operational Conversion Unit, No. 237 OCU, was formed on 1 March 1971 at Honington under Wing Commander A.W. Fraser. This unit's formation effectively started a reversal of the aircrew training roles between the Navy and the RAF. Following the disbandment on 25 February 1972 of No. 736 Squadron, No. 237 OCU would assume the responsibility for all Buccaneer training for both services. To concentrate all UK Buccaneer resources at one base, No. 809 Squadron moved south to Honington on 18 October 1972, breaking – albeit temporarily – an association between the Scottish base and the Buccaneer.

Initial equipment for the OCU comprised the inevitable two-seat Hunter T.Mk 7As and T.Mk 8Bs, along with a number of Buccaneer S.Mk 2Bs and interim S.Mk 2Bs, the first (XT287, ex-809 Squadron) arriving on 12 March 1971. The first long course (RAF No. 9) started in May 1971. During the 1970s the OCU had a war role of providing crews for the Buccaneer force, but in 1984, with the disbandment of the RAF Germany units, was given the specific wartime tasking of laser designation for RAFG Tornados and Jaguars, using the Pave Spike equipment. In October of that year, No. 237 OCU was the last of the Buccaneer units to vacate Honington and move to Lossiemouth. Its prowess in the spiking role resulted in it leading the Gulf War detachment. In the aftermath of Operation Granby and with the end of the Cold War, the RAF elected to run down its Buccaneer force as Tornados became surplus to requirements in RAF Germany. Training requirements for Nos 12 and 208 Squadrons decreased to the point where the OCU was disbanded on 1 October 1991. The training function continued to be handled for another year by a dedicated flight within No. 208 Squadron.

No. 237 OCU initially presented its badge (a teacher's 'mortarboard' superimposed on a pair of crossed cutlasses) directly on the aircraft's intake (above) but later adopted a circular red background (below).

Trials and test organisations

The first 20 Buccaneers were all NA.39 prototype/pre-production airframes for use by the manufacturer and test establishments to hasten the development and deployment of operational aircraft. They were ordered as one batch with serials XK486 to XK491 and XK523 to XK536. Two of these aircraft (XK526 and XK527) were later modified to S.Mk 2 standard, while some of the later development batch aircraft were delivered to the Navy for intensive flight trials.

Much later, four S.Mk 2B aircraft were purchased for dedicated test and trials work, one (XX897) being procured as part of an RAF batch but delivered to the RRE, while the remaining three (XW986, XW987 and XW988) were a separate batch ordered for the RAE.

Having been involved in initial trials with the NA.39s, the A&AEE at Boscombe Down used many airframes throughout the Buccaneer's long career. Shown above is XN976 while on the strength of the subordinate Royal Navy Test Squadron, while below is long-term A&AEE trials aircraft XT283. The badge on the fin is that of the Strike and Fighter Test Squadron.

A&AEE Boscombe Down

As its name implies, the Aeroplane and Armament Experimental Establishment, at Boscombe Down, is the UK's principal test organisation for new aircraft and weapons types. Over the years many Buccaneers have been on the strength of the A&AEE, some being assigned for short periods to perform specific test work, while others have been assigned for longer stints as general trials platforms.

XK489 was the first aircraft to arrive for trials at Boscombe Down, in the summer of 1959. Carrier trials began in January 1960, under the auspices of the A&AEE's 'C' Squadron. Other pre-production aircraft assigned to Boscombe at one time or another included XK523, XK526, XK528 and XK533. S.Mk 1s operated by the A&AEE included XN922 (hot weather trials in 1962), XN923, XN955 (assigned in 1967 to 'C' Squadron), XN968 and XN973.

S.Mk 2 operations by the A&AEE began with XN974 and XN976, assigned to the Naval Test Squadron and continued with XT283 (permanently assigned to the Strike and Fighter Test Squadron from 1987),

XT288, XV155, XV337 (permanently assigned from 1973 to 1984), XV350, XV866, XV869 and XW529.

Royal Aircraft Establishment/ Radar Research Establishment etc.

Like the A&AEE, the Royal Aircraft Establishment (later Royal Aerospace Establishment, Defence Research Agency and Defence Evaluation Research Agency) played a large part in the early development of the Buccaneer, not least because the agency's Bedford airfield was the site of the Buccaneer's first flight. Bedford also had a dummy carrier deck, and this was intensively used during early trials. Shortly after its first trials at Boscombe Down in the summer of 1959, XK489 flew to Bedford to begin field carrier landing trials. XK530 was another pre-production NA.39 operated by the RAE, flying principally from the main research site at Farnborough. For weapons tests S.Mk 1 XN923 was assigned to RAE West Freugh while S.Mk 2 XN975 spent time at Bedford, West Freugh and with the Radar Research Establishment (RRE) at Pershore. The latter facility undertook advanced radar work and operated a small number of Buccaneers at various times. When Pershore's runway closed in 1978, RRE flying operations moved to Bedford.

The RAE's own dedicated three-aircraft

batch of S.Mk 2Bs was delivered in early 1974 and was employed on a wide variety of trials at West Freugh and Farnborough. The aircraft made the move to Boscombe Down when the UK's aerospace test organisations were concentrated at the Wiltshire airfield under the auspices of DERA. XW986 and XW988 were withdrawn from use in August/September 1994, while XW987 continued to fly until February 1995. In 1979 this fleet had been joined by XV344 'Nightbird', which from 1982 had been the testbed for various thermal imaging and related systems. One further aircraft operated first by the RRE, and then the RAE, was XX897, converted in 1976 by Marshalls to carry a Marconi Foxhunter radar, as used by the Tornado F.Mk 2/3.

Left: Seen in 1970, this S.Mk 1 was used on RAE weapons trials at West Freugh, and later by the manufacturer and by the A&AEE.

Above: XW987 was one of three aircraft procured specifically for the RAE. Here it is seen in its final hybrid colour scheme.

Left: S.Mk 2 XN975 flew with both the RAE and RRE. The red panels were for conspicuity.

Above: The three RAE machines were delivered in a yellow/black scheme, displayed here by XW988.

XX897 was the Foxhunter radar testbed, initially procured for the RRE at Pershore. When Pershore closed, the aircraft moved to Bedford.

The Tornado GR.Mk 1 radar testbed, XT272, flew initially from Warton, but subsequently transferred to the RAE, flying from Farnborough and Bedford.

Blackburn/Hawker Siddeley/BAe

To speed the development and clearance process, Blackburn retained all 20 of the NA.39 prototype/early production aircraft (XK486-491, XK523-536) and operated them primarily from its Holme-on-Spalding Moor base, in close co-operation with the A&AEE and RAE. XK488 was also dispatched as the principal engine trials aircraft to Bristol at Filton and de Havilland at Hatfield. Only the last six were subsequently delivered to the Royal Navy, mostly to No. 700Z Flight. XK526 and XK527 were both converted to S.Mk 2 and XK527 became an important weapons/systems trials aircraft, testing munitions dispensers, Martel, Pave Spike and Sea Eagle.

The first S.Mk 2, XN974, was retained by the manufacturer for much of its career, and other Mk 2s on charge were XT288, XV350 (extended bomb door and weapons trials), XW525 and XW529 (Pave Spike trials). The latter was based at Scampton for some time with the BAe test fleet. BAe occasionally used the Buccaneer as a tanker to extend the range of Lightnings and Tornados on test work from Warton.

BAe Warton also operated the two Buccaneers equipped with Texas Instruments TNR (Tornado Nose Radar) by Marshalls. XT275 was converted in 1972, but crashed in 1978. XT272 was converted in 1973. Both aircraft remained on MoD(PE) strength and operated closely with the RAE and RRE, although they flew mostly from Warton. XT272 later operated from Farnborough before being withdrawn from use at Bedford.

Left: This photo shows XT272 at Marshall's after its conversion with Tornado Nose Radar. The aircraft was finished in extra dark sea grey.

Right: XK527 was probably the hardest-working of the manufacturer's fleet. It is seen here in 1983 in S.Mk 2D standard. It was withdrawn in 1991 and scrapped.

XW529 spent its life as a manufacturer's/A&AEE test aircraft, wearing a polar bear tail badge. It was instrumental in Pave Spike trials, and spent much of its later career attached to BAe's Scampton facility.

Ferranti

With its low-level performance and tractable airframe, the Buccaneer made a useful testbed for advanced fighter/attack radars. The first such use of the aircraft was of second prototype XK487, bailed to Ferranti at Turnhouse in 1960. It initially flew trials with the Buccaneer's own Blue Parrot radar, but was subsequently fitted with the radar intended for the TSR.2, carried in a TSR.2 radome. It was withdrawn from use in 1967.

Parked outside the Turnhouse facility, Ferranti's radar testbed is seen fitted with the radar and radome intended for the TSR.2.

South African Air Force

South Africa ordered 16 Buccaneer S.Mk 50s (serialled 411-426) in January 1963 under the terms of the Simonstown Agreement. The first aircraft flew on 9 January 1965. Relations between the UK and South Africa soured considerably during 1965, with the result that the near-certain follow-up order for 14 aircraft was never placed, while the UK government refused to replace the aircraft lost on its delivery flight.

No. 24 Squadron

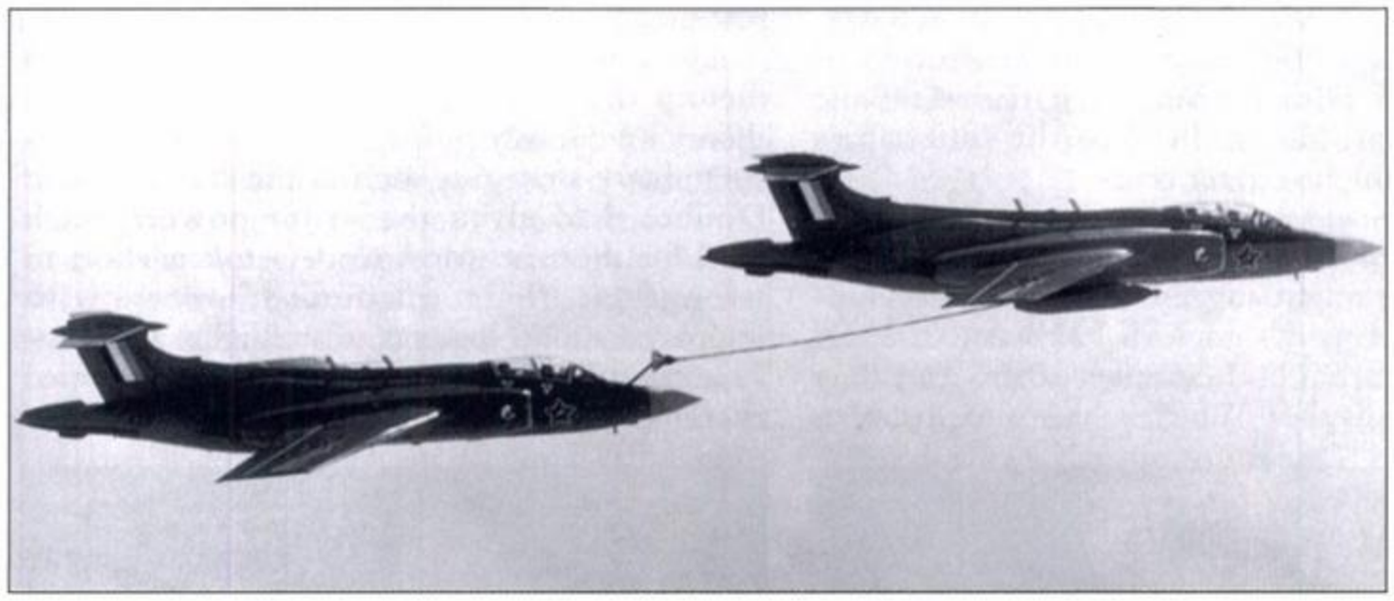
The SAAF's No. 24 Squadron had a distinguished wartime history flying Bostons and Marauders, and a short post-war incarnation between 1946 and 1951 flying Venturas. Chosen to be the sole South African Buccaneer unit, No. 24 reformed at Lossiemouth on 1 May 1965 under Commandant Bob Rogers, who was later to become chief of the SAAF. The first South African crews had begun training with No. 809 Squadron in January. Even after formation, No. 24 Squadron continued to use Royal Navy aircraft for training purposes until the first S.Mk 50 was delivered to Lossiemouth on 26 May, followed by seven more shortly after. By 27 October the first eight aircraft and their crews were ready for the long delivery flight, Commandant Rogers and his flight arriving at the Waterkloof base on 3 November. The loss of one aircraft during the delivery resulted in the second batch being dispatched by sea between August and October 1966.

In SAAF service the Buccaneer had a dual overland/maritime tasking. Bombs of 1,000 lb were the standard weapon, while for precision attacks the aircraft used Nord AS20 and AS30 missiles. Buddy refuelling was regularly practised. In February 1971 No. 24 Squadron employed AS30s against the grounded oil tanker *Wafra*, and in May 1972 used 1,000-lb bombs against the *Silver Castle*. Buccaneers were sporadically used during 'externals' (raids into Angola) from May 1978 to February 1988, including the use of AS30s on later missions. Losses slowly whittled the fleet down and by 1983 No. 24 Squadron had just five aircraft. The worst accident was on 24 November 1972, when two Buccaneers were lost in a mid-air collision. One aircraft was subsequently used by Atlas Aircraft as a trials aircraft. The four No. 24 Squadron aircraft flew a farewell mission from Waterkloof on 28 March 1991, and on 10 April aircraft 416 flew the last SAAF Buccaneer sortie, flying to the SAAF museum at Ysterplaat.

Above: A No. 24 Squadron S.Mk 50 puts on a spirited display. The Buccaneer fleet suffered a string of accidents, losing aircraft in 1969, 1970, 1972 (two), 1973, 1975, 1978 (two), 1979 and 1983. This reduced the fleet from 15 to five.

Below: The S.Mk 50s were initially delivered in a gloss two-tone scheme with full-colour national insignia. The No. 24 Squadron badge (a bird dropping a bomb against a split day/night background) was displayed on the intake sides.

Below: Buddy refuelling pods were supplied as part of the Buccaneer sale and were regularly used by the SAAF. Tanking provided the South African Buccaneers with an extended command of the strategic waters around the Cape.



Below: In the late 1970s the SAAF fleet was toned down by the adoption of matt paint and the removal of all markings with the exception of the serial number. At the time, the Buccaneer fleet was undertaking a growing number of raids into Angola.

Luftwaffe Nachtflieger

Part 1: 1939-Spring 1942

In 1939, Germany had extensive searchlight and flak defences, but no dedicated night-fighter Gruppen. The increasing number of RAF night raids were at first countered with techniques little different from World War I. By spring 1942, there were four dedicated night Geschwader, the scores of the *Experten* were mounting and airborne radar was making its mark – but, by then, there were 1,000 bombers at a time in Germany's skies.

The Messerschmitt Bf 110, outclassed as a day fighter, adapted easily to the nocturnal role. With the fitting of increasing amounts of guns, armour and equipment, performance dropped off until the Bf 110G arrived in mid-1944. These Bf 110C-4s of 7./NJG 4 are representative of the backbone of the Nachtjagdgeschwader in the first three years of the war.

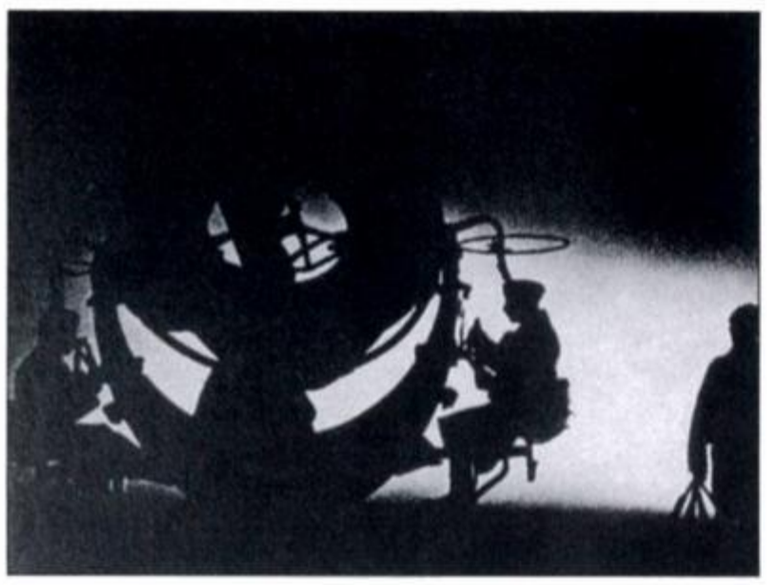
It is now commonly accepted that the Battle of Britain began on 10 July 1940. Over the next 16 weeks more than 500 pilots of RAF Fighter Command gave their lives in defence of their country; five times that number of Luftwaffe pilots and crew members perished.

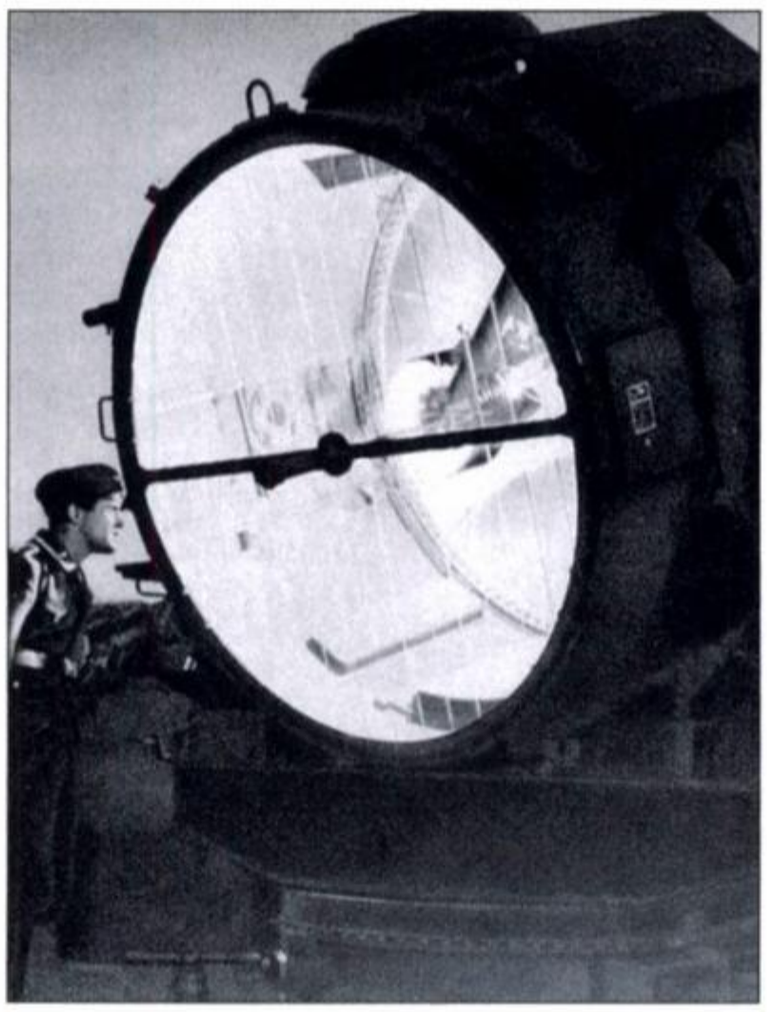
On the very eve of that historic conflict another battle was joined – all but unremarked at the time, except by those few who were directly involved – a battle, moreover, which lasted not 16 weeks, but which was to be waged for almost five years. A battle which finally ended with the reported loss of more than 3,000 Luftwaffe night-fighter aircrew killed or missing, and which had cost the lives of over 50,000 men of Bomber Command to win.

Of the 64 British bombers which had set out into the gathering dusk over the North Sea on 8 July 1940 to attack targets in Holland and northern Germany, all but one returned safely. That one was a Whitley of No. 10 Squadron. It had lifted off from Dishforth in Yorkshire at 20.58 with orders to bomb the German naval base at Kiel. A last transmission was received from the aircraft at 01.45. Five minutes later, at 02.50 local time (which was running one hour ahead of British Summer Time) on the morning of 9 July 1940, it was shot down into the sea off the island of Heligoland by a German night-fighter. The demise of Whitley N1496 warrants inclusion as a brief footnote to the history of World War II in the air, for it represents the first 'official' kill credited to the Luftwaffe's embryonic night-fighter arm.

History – and aviation history, in particular – is not always as precise as its subsequent chronicling might suggest. The early development of Germany's nocturnal airborne defences was a protracted and complex affair. And long before the hapless Whitley had sunk beneath the surface of the North Sea, pioneering Luftwaffe night-fighters had already scored their first successes and suffered their first losses.

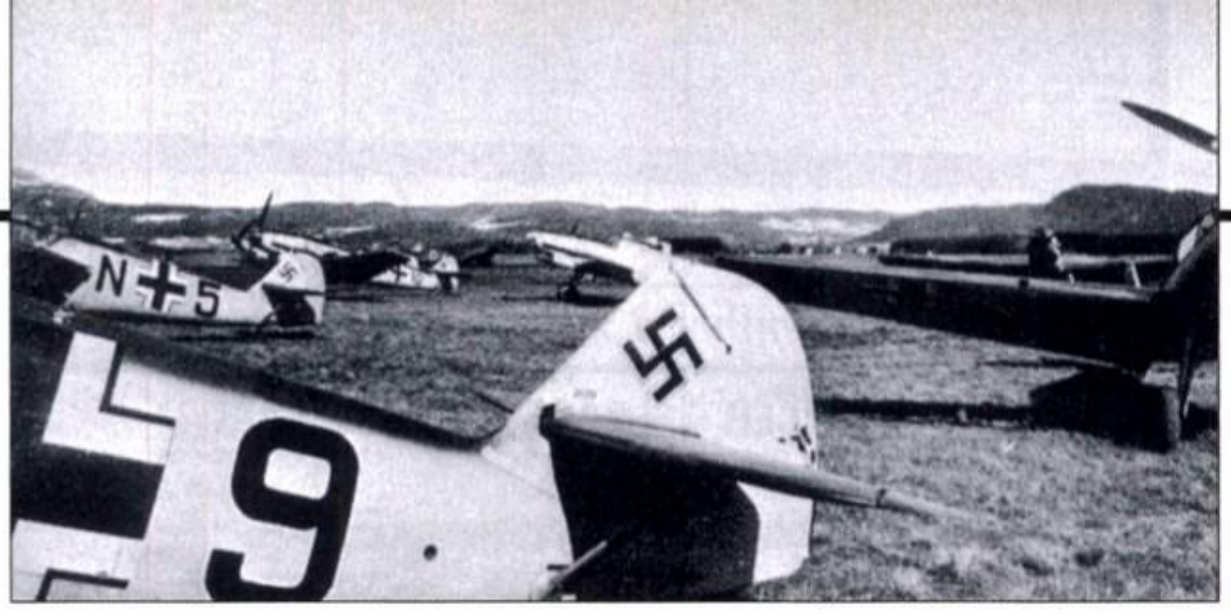
The cult of the bomber and the perceived dictum that it would 'always get through', a theory assiduously propagated between the wars by military strategists such as the Italian Giulio Douhet, had given the major powers much food for thought. Most made a token effort to strengthen their ground defences with improved sound locators, searchlights and anti-aircraft artillery. Weimar Germany was denied even these small measures. The Versailles Treaty





Above and right: Throughout the war, the Luftwaffe operated huge numbers of anti-aircraft (flak) guns and searchlights as the primary methods of night air defence, assisted by sound locators (above) and radar. In 1939, over two-thirds of Luftwaffe manpower served in the flak arm. The most common type of searchlight was the flakscheinwerfer 37 with a 150-cm (59.1-in) mirror. In the early war period they were grouped in batteries of nine lights, with three batteries controlled by a regiment. In 1942, the 200-cm (78.7-in) flakscheinwerfer 40 was introduced, usually as a radar-directed master light.

A battery of 88-mm flak guns goes into action in November 1939. The layout of flak batteries became more sophisticated as the war progressed, with guns being emplaced in precise patterns around 'vulnerable points' rather than in unprotected lines as shown here.



Above: Bf 109Ds of IV.(N)JG 2 were deployed to Norway in 1940, reportedly for the sole reason of posing for propaganda pictures.

Right: This early Bf 109s (Cs or Ds) may belong to IV.(N)/JG 2. This offshoot of the 'Richthofen' Geschwader had two night Staffeln until they were taken away to become II./NJG 1 in June 1940.

had restricted its anti-aircraft weaponry to just seven batteries, each of four 77-mm lorry-mounted cannon – a grand total of 28 guns in all! It was not until Adolf Hitler came to power in 1934 that anti-aircraft rearmament began in earnest (11 years later, in 1945, the Luftwaffe's *flakartillerie* alone comprised almost 32,000 pieces).

Another, and more immediately tangible, manifestation of the new regime's intentions was the rapid expansion and multiplication of Reichsluftwaffe flying units. The first of them to be ceremonially 'unveiled' to the public, amid much Swastika-beflagged pageantry, was the Jagdgeschwader 'Richthofen' at Berlin-Döberitz on 14 March 1935. For the next 4½ years, as Europe drifted inexorably towards another war, the 'Richthofen' fighters remained the premier showcase unit of the Third Reich's burgeoning air arm. Based close to the German capital, it played host to numerous visiting dignitaries from both home and abroad, parading its apparent strength and preparedness in order to woo would-be allies, or to impress potential foes, as the occasion demanded.

The vast majority of the military hierarchy fully supported Hitler's race to re-arm, but there were some, more cautious, who could foresee the dangers inherent in embarking upon an expansionist foreign policy backed up by shows of offensive force alone. Without a corresponding increase in defences, Germany would be vulnerable to retaliatory attack. Both the British and French air forces had recently introduced 'heavy' night-bombers into service (the Handley Page Heyford late in 1933 and the Amiot 143M in 1935). The best defence against the night-bomber, some argued, was the night-fighter.

Consequently, although not a single night-fighter had featured in the large-scale Wehrmacht manoeuvres of 1936 and 1937, a limited series of night trials was held shortly thereafter. They involved Ar 68s, flown by pilots of II./JG 132 'Richthofen', exercising in conjunction with the searchlights of Berlin. Although rudimentary in the extreme – single-seat biplanes landing and taking off from a grass strip by the light of gooseneck flares was not exactly a quantum leap forward from the conditions which had existed at the end of World War I! – these initial trials obviously struck a chord with the authorities. More were to follow in short order. The less reverent among the 'Richthofen' flyers joked that they could always tell when the Führer was about to make another of his territorial demands: they would be up practising the nocturnal defence of his capital the week before!

There was more than a grain of truth in these assertions. At the height of the Sudeten crisis in September 1938 another experimental detachment was set up at Döberitz. Commanded by Oberleutnant Blumensaat, a dedicated night-fighter advocate, this Staffel-strong unit of Ar 68s was even given an official designation: 10.(N)/JG 132. And five months later, when Hitler was preparing to occupy the remainder of Czechoslovakia, this detachment was revived, again under Blumensaat, as 10.(N)/JG 131 (the parent 'Richthofen' Geschwader having itself undergone a minor change in designation in the interim).

JG 134 and JG 234

Two other pre-war Jagdgeschwader established similar, albeit even shorter-lived night-fighter Kommandos: JG 134 'Horst Wessel' and JG 234 'Schlageter'. The latter detachment was led by Leutnant Peter Boddem, who was subsequently to emerge as the Condor Legion's fourth-ranking scorer with 10 enemy aircraft to his credit. It is not known, however, whether Boddem – who was killed in the crash of a Ju 52 transport in March 1939 when returning from his second tour with the Legion – was involved with the three Ar 68s sent to Spain for night-fighter trials under operational conditions. Based at La Cenia in southern Catalonia, this trio mounted a number of 'twilight' patrols with singular lack of success before being diverted to ground-attack duties.

As war loomed ever larger, the RLM (Reichsluftfahrt Ministerium/Air Ministry) demonstrated a growing commitment to the formation of a viable night-fighter force. The 'Richthofen' Staffel at Döberitz was put on permanent establishment. Exchanging its Ar 68s for Bf 109Ds, it became 10.(N)/JG 2 after the wholesale unit redesignations of 1 May 1939. Exactly three months later Lehrgeschwader 2, the second of the Luftwaffe's two operational development groups, was ordered to set up a specialised night-fighter Staffel, 11.(N)/LG 2, to carry out official trials to determine night-fighting tactics and procedures.

At the same time, a suggestion was made that each of the five new Jagdgeschwader scheduled for activation in the expansion programme of 1939 – JGs 20, 21, 70, 71 and 72 – should be made up of two standard Gruppen of day-fighters and one night-fighter Gruppe. These plans were overtaken by events, however. The outbreak of hostilities on 1 September 1939 saw almost all those components of the above Geschwader which had been created prior to that date serving in the day-fighter role. There were just two exceptions: 10. and 11./JG 72.

Thus, with the formation of a night-fighter unit by JG 26 'Schlageter' in the opening hours of the conflict, the Luftwaffe's night-fighter 'arm' at the beginning of World War II consisted of five separate and widely-dispersed Staffeln.

The Phoney War

While the bulk of the Wehrmacht was reducing Poland in a campaign which lasted just 18 days, the German High Command was keeping an anxious eye on the Western Allies. But the expected fleets of night-bombers failed to materialise. The RAF, for one, had revised its policy since the mid-1930s, and Bomber

Bf 109D night-fighter

Early Luftwaffe night-fighters were assigned to semi-autonomous Staffeln and wore standard day camouflage, the only indication of their special role being the 'N' code ahead of the Balkenkreuz. This Bf 109D was flown by Johannes 'Mäcki' Steinhoff of 10.(N)/JG 26 in Denmark in late 1939. Steinhoff ended the war as an Me 262 pilot with a total of 176 victories.

Wolfgang Falck is seen at Arnhem in October 1940. Falck was the Geschwaderkommodore of NJG 1 for three years from June 1940 and is credited with laying the foundations of the night-fighter arm. He scored no night victories himself.

Nachtjagd Order of Battle, September 1939

UNIT	COMMANDING OFFICER	BASE	AIRCRAFT
Luftflotte 1 (Luftgau-Kommando III, Berlin)			
10.(N)/JG 2	Hauptmann Erich Blumensaat	Straussberg	Bf 109D (9/9)*, Ar 68
Luftflotte 2 (Luftgau-Kommando VI, Münster)			
10.(N)/JG 26	Oberleutnant Johannes Steinhoff	Bonn-Hangelar	Bf 109D (9/9)*, Ar 68
Luftflotte 3 (Luftgau-Kommando VII, Munich)			
10./JG 72	Oberleutnant Josef Fözö	Böblingen	Ar 68 (17/11)*
11./JG 72	Hauptmann Hans-Georg von Kornatzki	Böblingen	Ar 68 (16/11)*

* unit establishment/serviceable aircraft

Command now placed its faith in mutually-supporting, heavily-armed formations of day-bombers. German cities nevertheless experienced a number of nocturnal air raid warnings during the early weeks of the war, nearly all false alarms. One such, sounded over Berlin on the night of 16/17 September, resulted in the night-fighters' first casualty. Two of the aircraft scrambled, a Bf 109 of I./JG 2 and an Ar 68 of 10.(N)/JG 2, both crashed, killing their pilots. It was assumed that they had been blinded by the reflected glare of the capital's searchlight batteries.

Meanwhile, the dearth of nocturnal air activity in the southwest over the Franco-German border resulted in the rapid disappearance of both 10. and 11./JG 72. Official records are reticent on the subject, but it would appear that the former, which had been operating alongside II./JG 53, was soon relieved of its Ar 68s and assimilated into the ranks of the famous 'Ace of Spades' Geschwader. Likewise, the personnel of 11./JG 72 provided a ready nucleus to assist in the formation of II./JG 52.

Some weeks later this latter Gruppe had another brief flirtation with night-fighting, albeit under protest. By this time Allied reconnaissance machines were mounting the odd foray under cover of darkness into German airspace. Although no damage was caused, the Luftwaffe High Command obviously felt that such practices were to be discouraged. Orders were therefore passed down that one Staffel of II./JG 52 was to relinquish its Bf 109s and receive instead Heinkel He 51 biplanes with which it was to fly anti-intruder night-fighter patrols.

The Staffel selected for this dubious honour, Oberleutnant August Schumann's 5./JG 52, was not exactly enamoured of the prospect. In fact, so long and loud were 'Rabatz' Schumann's protestations that his unit was eventually allowed to keep its Bf 109s – but still had to take delivery of the dozen elderly biplanes which arrived a few days later. So, for the next two months, 5./JG 52 found itself in the curious – not to say unique – position of operating its Messerschmitts by day and Heinkels by night. It was not until the whole Gruppe moved up from Böblingen to Lachen-Speyerdorf that the scheme was finally abandoned and the He 51s could happily be left behind.

The continued paucity of nocturnal targets convinced the RLM that there was now no need to add further to the Luftwaffe's night-fighter defences. They did, however, make one organisational change during the winter of 1939/40 when the three hitherto-autonomous Nachtstaffeln were combined to form a single Gruppe. Commanded by Hauptmann Blumensaat, IV.(N)/JG 2 was initially deployed along the Reich's northern seaboard: the Gruppenstab and 11. Staffel (ex-11.(N)/LG 2) at Jever, the original 10.(N)/JG 2 out on Langeoog, one of the offshore Frisian islands, and 12.(N)/JG 2 (ex-10.(N)/JG 26) at Lüneburg. The latter subsequently transferred to Marx, while the Gruppe also temporarily deployed a small Kommando at Rostock on the Baltic coast.

It was not over these northern waters that IV.(N)/JG 2 achieved its first success. By the spring the Gruppe had been ordered to relocate several detachments inland, and on the night of 20/21 April 1940 – nearly eight months after the outbreak of hostilities – Oberfeldwebel Willi Schmale finally scored the Luftwaffe's first night-fighter kill of World War II when he shot down a France-based Fairey Battle of No. 218 Squadron, AASF, which had been busy 'Nickelling' (leaflet-dropping) near Crailsheim. Of the three-man crew of Battle P2201 only

Another propaganda ploy was to paint some of the few Heinkel He 100Ds in bogus night-fighter colours and present them as 'He 113s' in the spring of 1940. The fictitious unit emblem is of interest.

Development
The first of the Ar 68 series, the Ar 68A (D-IKIN), powered by a BMW VId engine, first flew in late summer 1934. It was followed by the Ar 68B and C (both Jumo-powered), the BMW-powered Ar 68D and the Ar 68E, the latter with a Jumo fitted with a two-stage supercharger. When the RLM introduced Versuchs numbers, the Ar 68 D and E prototypes were redesignated Ar 68 V4 and V5, respectively.

Structure
The Ar 68 was constructed around an oval-section framework of welded steel tubing. The fuselage was metal-skinned from the nose to the cockpit and along the spine to the tail, the remainder being fabric-covered. The wings were a fabric-covered wooden structure. The fixed tail surfaces were all metal, with fabric-covered elevators and rudder. The metal-covered landing flaps, stretching the whole length of the lower wing, were an early, if not first, use on a biplane.

He 51 versus Ar 68
The Heinkel He 51 beat the Ar 68 into service to be the first fighter of the rebuilt Luftwaffe. Basic performance figures of the BMW-powered He 51C and Ar 68F were almost identical, but the Heinkel was much harder to fly and suffered high training attrition. General Ernst Udet himself flew an Ar 68F in comparative flight trials with a Heinkel flown by one of the best pilots in the Luftwaffe, and so comprehensively out-fought it that Arado production was soon increased. Allocations of the Jumo 210 were made to Arado, resulting in the improved Ar 68E.

Engine
Ar 68E-1s were powered by the 690-hp (515-kW) Junkers Jumo 210Ea supercharged inverted V-12 inline engine. This powerplant offered better altitude performance than the BMW VI upright V-12, the latter being essentially a low-altitude engine.

Arado Ar 68F-1 11./JG 72 Böblingen September 1939

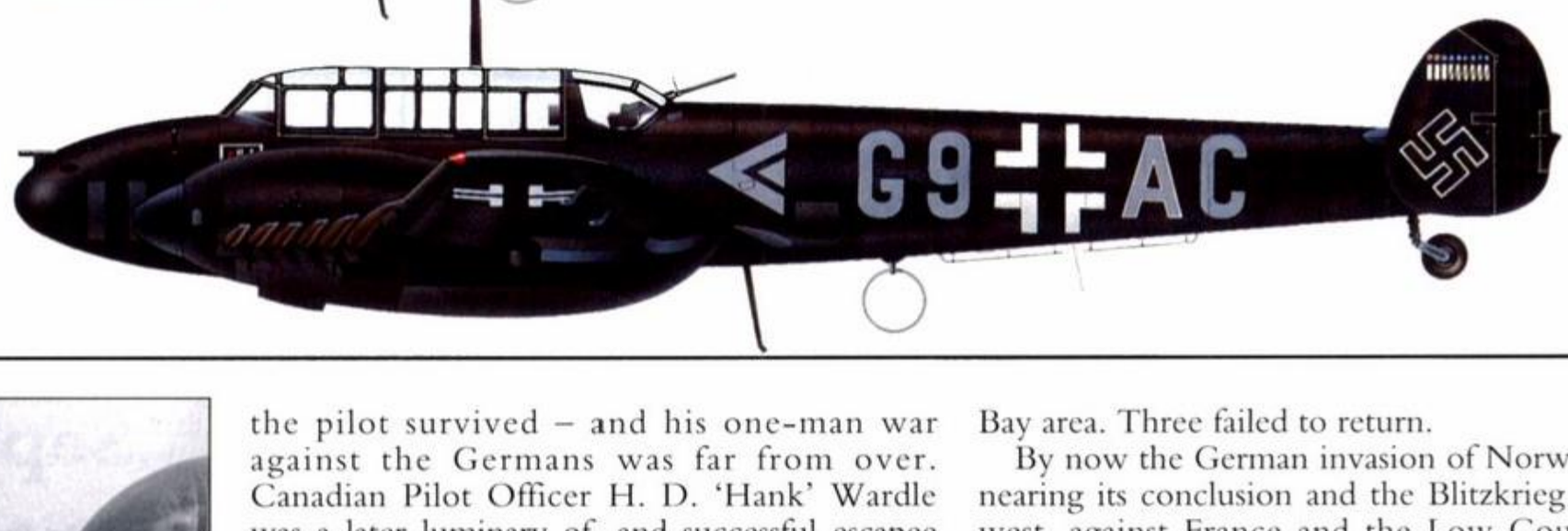
The first Arado Ar 68s, BMW-powered Ar 68F-1s, entered service in 1936 with I./JG 134 at Werl. By 1938, before the Bf 109 became dominant, the Ar 68E (with the Jumo 210) was the most numerous type in the fighter arm. In 1938, two Ar 68Es were sent to Spain for operational trials and were used as night-fighters with Grupo 9 based at La Cenia. This aircraft belonged to one of two Staffeln (10. and 11./JG 72) based together at Böblingen near Stuttgart. In 1940, the last Arados were sent to fighter-training schools.

Armament
Series-produced Ar 68 fighters were armed with two MG 17 machine-guns with 1,000 rounds of ammunition. They were mounted above the cowling and synchronised to fire through the propeller, in true World War I fashion. A container for six SC 10 fragmentation bombs could be carried for close-support missions.

Bf 110Cs of NJG 1

Werner Streib, Staffelkapitän of 2./NJG 1 at Gütersloh in July 1940, was to become one of the top six night-fighter pilots. At this time he flew a Bf 110C-1 in standard Zerstörer camouflage with the *Englandblitz* Nachtjagd badge.

Geschwaderkommodore of NJG 1, appeared at Arnhem-Deelen in autumn 1940. The yellow fuselage band was seen on some early black-painted Bf 110s, but compromised camouflage and was removed. The code letters were grey for lower contrast, unlike the Balkenkreuz which was applied to RLM specifications.



Walter Ehle, the Gruppenkommandeur of II./NJG 1, flew this Bf 110C-4 from Arnhem-Deelen in October 1940. Ehle's rank chevron and the first nine of his eventual 38 kills are marked on the aircraft. The individual letter on these all-black aircraft was usually outlined in a lighter colour rather than painted in a different shade.

Armourers replace the top cowl covering the MG 17 machine-guns on a Bf 110F. A tiny figure '4' appears under the Nachtjagd insignia, possibly indicating the Staffel.

Below: During the early part of the war, German night-fighters often operated over flak-defended areas, with inevitable consequences on occasion. Oberleutnant Uellenbeck of II./NJG 1 crash-landed in a field on Schleswig-Holstein after such an incident.

the pilot survived – and his one-man war against the Germans was far from over. Canadian Pilot Officer H. D. 'Hank' Wardle was a later luminary of, and successful escapee from, the notorious Oflag IVC prisoner-of-war camp, now better known as Colditz Castle.

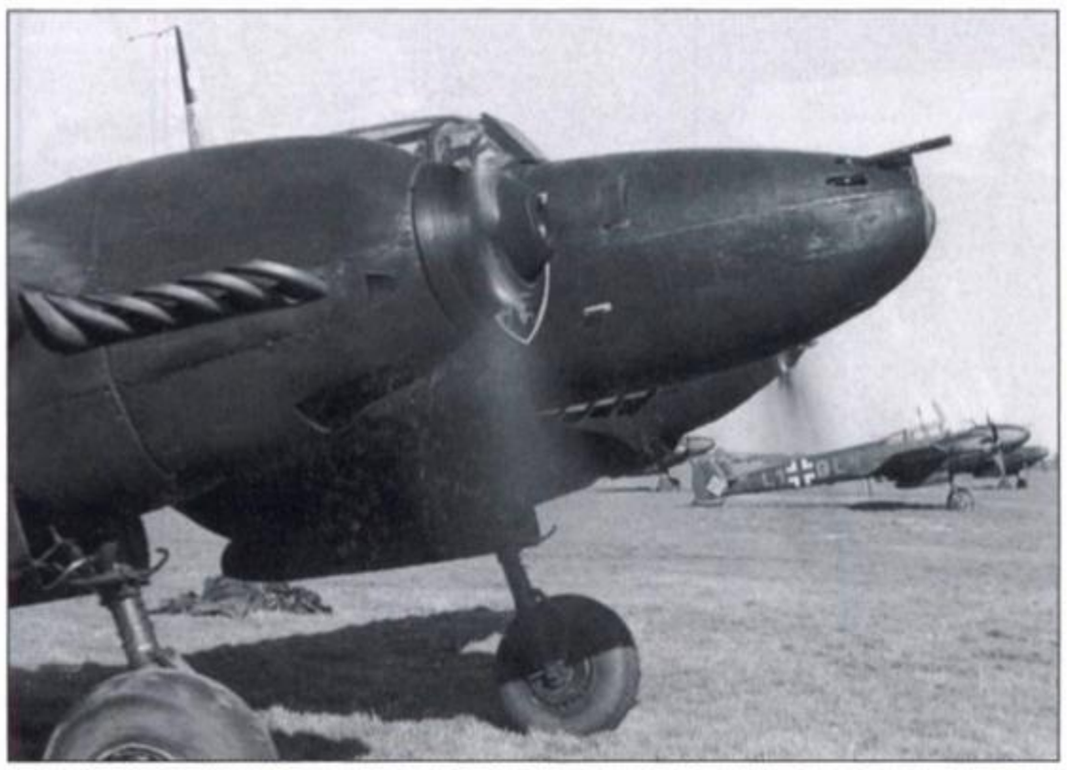
Five nights later it was the turn of one of the coastal pilots to claim the Gruppe's second victory. Oberfeldwebel Hermann Förster's victim, believed to be Hampden P1319 of No. 49 Squadron, which he shot into the sea off the southern tip of the island of Sylt, was the first aircraft of RAF Bomber Command to be lost to a Luftwaffe night-fighter. It had been one of 28 Hampdens dispatched to lay mines in the Kiel Bay area. Three failed to return.

By now the German invasion of Norway was nearing its conclusion and the Blitzkrieg in the west, against France and the Low Countries, was about to be launched. Neither campaign brought any success to IV.(N)/JG 2, which was peripherally involved in both. By this time, too, the British had been forced to rethink their bombing strategy yet again. A series of costly daylight raids against Germany's coastal belt late in 1939 – culminating in the disastrous Battle of the German Bight on 18 December, when 12 of an attacking force of 22 Wellingtons had been shot down by Luftwaffe fighters (including Johannes Steinhoff's 10.(N)/JG 26, operating on this occasion by day) – had proved that the concept of the self-defending daylight bomber formation was not simply flawed, but unsustainable. The realisation and acceptance of this hard truth was a major turning point in Britain's prosecution of the air war against Hitler's Germany. Henceforth, with but a few well-publicised exceptions, Bomber Command's main offensive would be restricted to the hours of darkness.

The first German town to be raided by night was München-Gladbach (today's Mönchengladbach), which was attacked by a mixed force of 37 Hampdens and Whitleys on 11/12 May 1940. Although achieving minimal results, this event had a profound effect on the Luftwaffe High Command. They, too, now had to revise their stance. The formation of an effective night-fighter arm had suddenly become a matter of some urgency. However, rather than just expand Major Blumensaat's IV.(N)/JG 2 (whose performance to date had, in all honesty, made very little impact on either the enemy or its own superiors), the RLM planning staff turned to a report – penned by the 29-year-old Kommandeur of a Zerstörergruppe based in Denmark – which had landed on their desks.

Hauptmann Wolfgang Falck's I./ZG 1 had been one of the Luftwaffe units assembled for

A Bf 110F, aircraft 'C' of II./NJG 1, is refuelled for the night's flying. The main night-fighter of 1940-42 was the Bf 110C/D series. Bf 110D-3s introduced the DB601N engine which used 96-100 octane C3 fuel (versus 87 octane B4 in earlier models) and had provision for two types of drop tank.



Bf 110D-1s of I./NJG 3 are seen in October 1940, the month of the Geschwader's formation, probably at Vechta. The aircraft in the background is still carrying the codes of 7./LG 1, the remains of which the new unit absorbed.

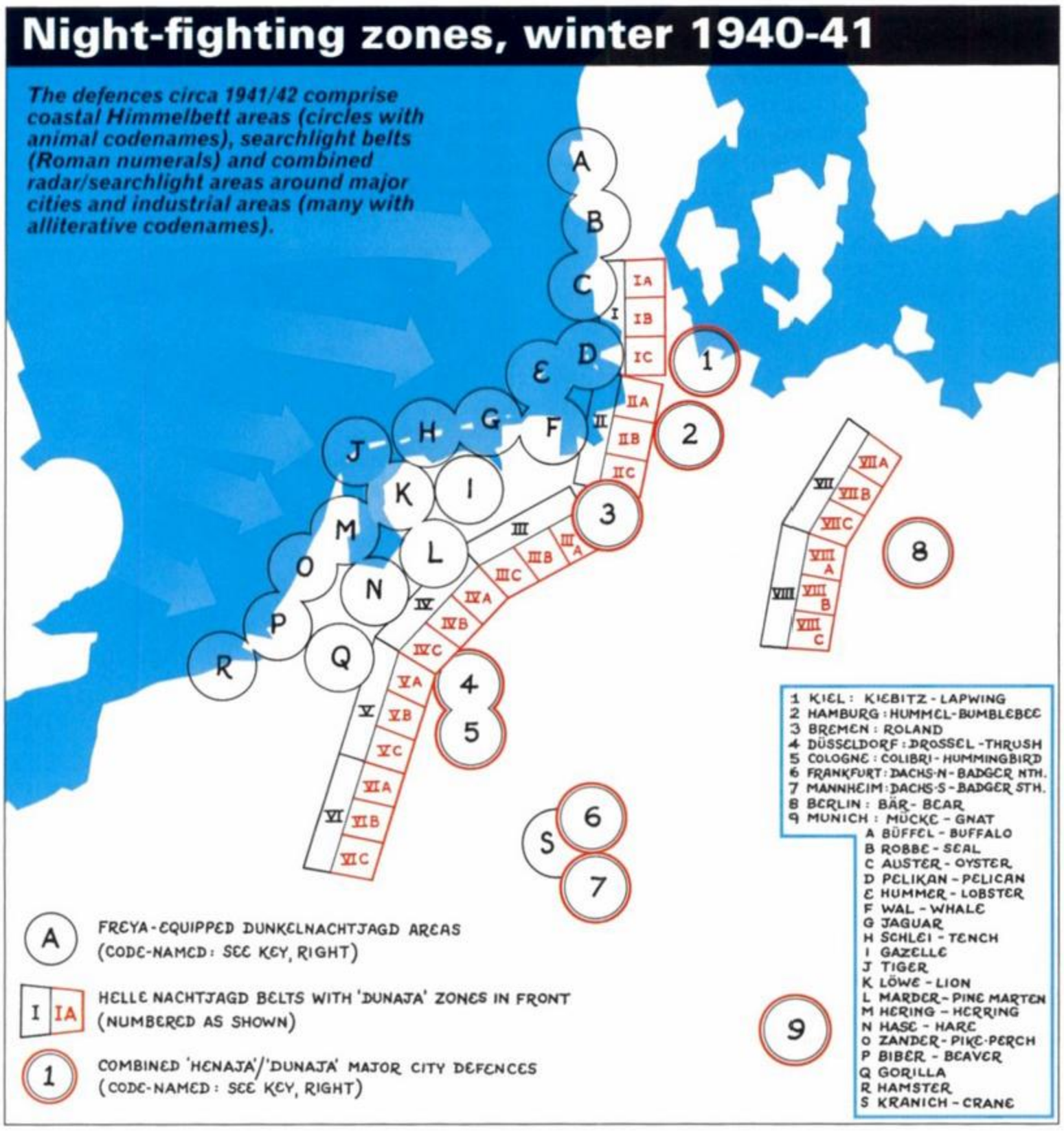
the invasion of Norway. Early in April 1940 it had transferred from Düsseldorf to Schleswig, and thence to Aalborg-West in newly-occupied Denmark. It was while at Aalborg that the Gruppe not only heard – and sometimes even saw – RAF night-bombers en route to and from nearby targets, but also suffered a series of night raids on its own field.

Falck was convinced that his own Gruppe could itself provide the best defence against such unwelcome attentions. First he set about establishing his Zerstörers' night-flying capabilities. A series of unofficial 'trials' using his most experienced crews demonstrated the Bf 110's nocturnal potential. They also proved that aircraft were clearly visible against the light northern night sky and showed, too, that – contrary to the tactics employed by day – the best method of attack would be from below.

Armed with this knowledge, Falck next approached his opposite number at the nearby coastal radar site. Together they worked out a procedure whereby a fighter would circle in a fixed 'waiting zone' before being vectored by radio towards an incoming bomber picked up on the ground radar. What Falck had done, in effect, was to lay down the guidelines for the opening rounds of the night-fighter war to come.

Eager to put his theories to the test, Falck – together with five of his best pilots (Streib, Ehle, Victor Mölders, Lutz and Thier) – set up what he somewhat grandiloquently entitled his 'Dämmerungsbereitschaftsflotte' (literally, 'twilight readiness fleet'). But he was caught quite unprepared by the RAF's night raids of 30 April/1 May on airfields in southern Norway and Denmark. Falck, Streib and Thier scrambled after the departing bombers. Despite the lack of all radio contact with their intended ground control, each managed to intercept and engage an enemy bomber. Although no kills were achieved – at the first burst of fire all three targets immediately sought the safety of a low-lying layer of sea mist – Falck had proven the practicability of his ideas.

Seventy-two hours later, however, I./ZG 1



Aircrew of II./NJG 1 discuss the forthcoming night's flying. The officer at right is Oberleutnant Eckart-Wilhem von Bonin, a future 39-victory ace who became Gruppenkommandeur of this unit in November 1943.

Above: Wolfgang Falck's driver delivers him to his Bf 110. The eight victory bars are a slight mystery: Falck was only credited with seven day Zerstörer kills and none by night. A Geschwaderkommodore's pennant flies from his car's mudguard.

Right: General der Flieger Albert Kesselring greets Hauptmann Falck on a visit to I./ZG 1 at Kirchhellen. Falck's 'twilight' experiments were interrupted by the unit's transfer to this Ruhr base to take part in the assault on France.

was moved down to Kirchhellen in the Ruhr in preparation for the forthcoming Blitzkrieg against France and the Low Countries, and all thoughts of further night-fighter experimentation were shelved. It was not until after the collapse of France, and Bomber Command had begun its assault on Germany's towns, that somebody in Berlin remembered the lowly Hauptmann's pioneering report. No further time was lost. On 22 June 1940 Falck was ordered to leave his 1. Staffel at Le Havre (where it was to form the nucleus of a new fighter-bomber unit) and return to Düsseldorf with the remainder of I./ZG 1 to activate the Luftwaffe's first-ever Nachtjagdgeschwader.

Nachtjagd comes of age

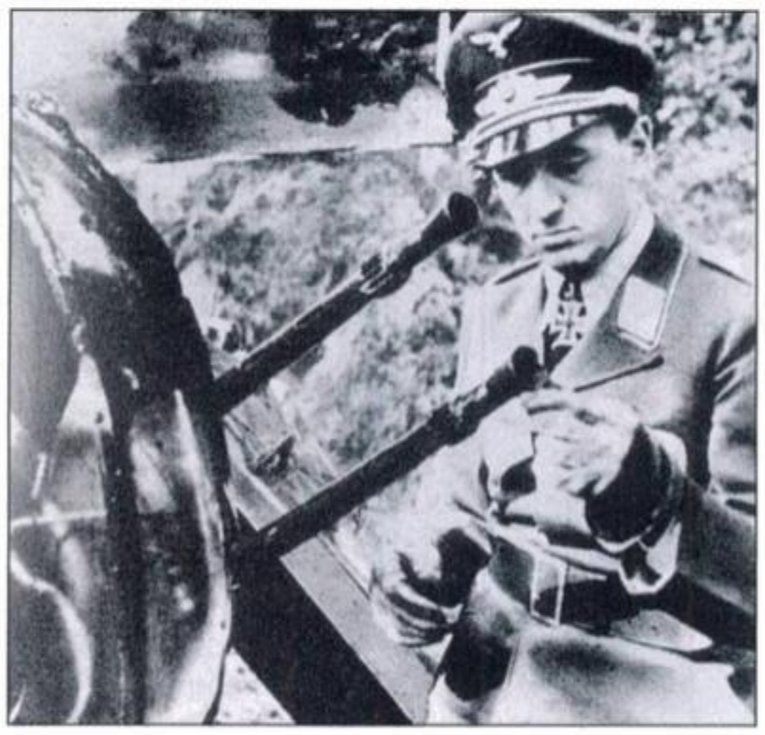
On 26 June 1940 Hauptmann Wolfgang Falck was officially appointed Kommodore of NJG 1. It was the first time in Luftwaffe history that a Hauptmann had been given command of a Geschwader (although Falck was soon to receive promotion to major). There were as yet no night-fighter schools, of course, so Falck's pilots attended a brief blind-flying course at Gütersloh. Not all wanted to give up day operations, preferring instead to remain with the Zerstörer arm for the next stage of the fight against the RAF over southern England, where, they confidently predicted, they would repeat the success they had just enjoyed in France.

Falck made good the gaps they left by trawling the day-fighter schools for volunteers for his erstwhile but depleted I. Gruppe, which had now been taken over by Hauptmann Günter Radusch under its new designation of I./NJG 1. Two further events of that same 26 June were the filling of the vacant 1. Staffel slot by the assimilation of another ex-Zerstörer unit, 10./ZG 26, and the redesignation of the original IV.(N)/JG 2 as II./NJG 1. In less than a week, however, II. Gruppe underwent another change of identity by becoming III./NJG 1. On 1 July it was decided that the Bf 110s of I. and III./NJG 1 (the latter was finally being relieved of its ageing Bf 109Ds!) would be employed in the nocturnal defence of the homeland, while an entirely new II. Gruppe – composed of longer-legged Do 17s and Ju 88s – was formed to carry out night-intruder missions over England.

Wolfgang Falck was not only instrumental in creating the Luftwaffe's night-fighter arm, he also introduced the emblem which was to become its universal symbol. Fully appreciating the real value and sense of identity imparted by a unit badge, he had invited suggestions for a Gruppe emblem when first taking over command of I./ZG 1 in the spring. Victor Mölder's winning design featured a pale-blue shield containing a segment of the globe showing the area of the North Sea. Depicted above this was a diving white falcon (taken from the Falck family crest) superimposed upon a red lightning flash which was striking southern England. When the Gruppe's role changed, and Falck was tasked with forming a night-fighter Geschwader, it was a simple matter to alter the light-blue background of the sky to one of inky black.

As Falck himself later explained: "This emblem was not just used on the aircraft, but appeared on all the Geschwader's vehicles as well. In addition, I had it made into small lapel pins which all members of the Geschwader were permitted to wear. This outward sign of 'belonging' should not be underestimated. After a few weeks' probation each new member of the Geschwader would be presented on parade with his lapel pin as a symbol of acceptance. Likewise, it could be removed if there were any breaches of discipline. For transgressions by the

Werner Streib was to become the sixth-highest-scoring night-fighter ace with 65 night victories, and was awarded the Knight's Cross on 6 October 1940. Here he examines the tail armament of one of his victims, a Wellington.



NJG 3 Bf 110C

As with many early Bf 110 night-fighters inherited from heavy day fighter units, this Bf 110C retained its earlier Zerstörer finish complete with 'Haifisch' (shark-mouth), a marking normally associated with II./ZG 76. It was flown by Oberleutnant Walter Borchers, Staffelkapitän of 8./NJG 3 at Luneburg in March 1942. Borchers had scored 11 day kills and added another 48 by night.

Cones of searchlights and bursts of flak reach up to a damaged bomber which turns back over a German city, one engine afire. A damaged bomber was a particularly easy target for night-fighters.

Below: A timelapse photograph, taken through trees, shows a hit on an RAF bomber, which flies straight and level for a while before plunging in flames to the ground.

individual reflected badly upon the unit as a whole.

"As the Nachtjagd arm got bigger and bigger, with new Geschwader being formed – first within the Division, and then as part of XII. Fliegerkorps – and increasing numbers of flak, searchlight and signals regiments were attached, this badge was used by all units, sometimes with minor changes. NJG 1, for example, had a white surround to the shield, NJG 2 red, and NJG 3 yellow. Some Geschwader differentiated between their component Gruppen by incorporating a second or third horizontal bar across the top of the shield; others added a Roman numeral."

NJG 1's first 'official' kill

Such expansion was still some months away, if not years. NJG 1 was very much on its own and unsupported during the first weeks of its existence, but nonetheless managed to score the Nachtjagd's first 'official' kill during this period. Perhaps not surprisingly, it was one of the more experienced members of the ex-IV.(N)/JG 2 – the same Oberfeldwebel Förster who had claimed the mine-laying Hampden off Hörnum on 25/26 April – who intercepted and shot down the No. 10 Squadron Whitley near Heligoland in the early morning hours of 9 July 1940 as described in the opening paragraphs.

Although promoted to major, Falck was still 'only' a Geschwaderkommodore and did not carry the necessary clout to be in overall control of the various branches which together would constitute the new Nachtjagd organisation. A command structure at divisional level was needed to co-ordinate all night-fighting activity, and orders for the creation of just such a Nachtjagddivision were cut on 17 July 1940. A week later a divisional staff was established in Brussels, and on 1 August the first Gefechtsstand (literally, 'Battle HQ', but in fact an attractive 17th-century castle) was occupied at Zeist, near Utrecht, in the Netherlands.

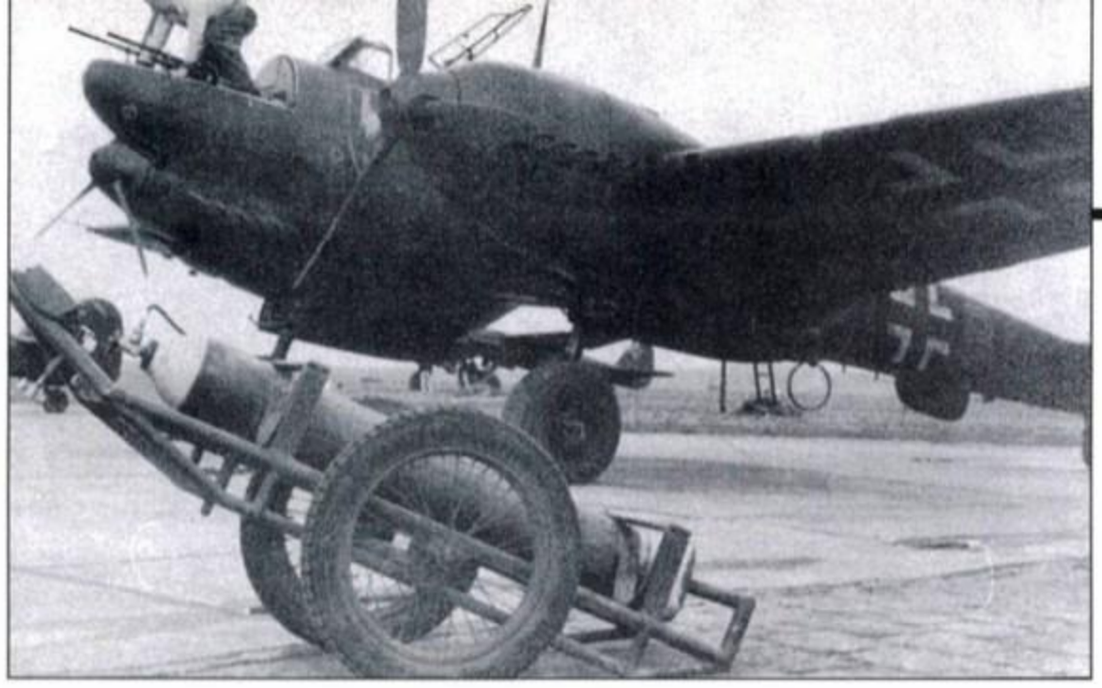
The Luftwaffe's hitherto decidedly makeshift night-fighter force finally had a command framework of its own commensurate with the task in hand. The officer selected as divisional commander was 43-year-old Generalmajor Josef Kammhuber, a World War I infantryman who had remained in the post-war Reichswehr before transferring to the air arm in 1933. Kammhuber had latterly been Kommodore of KG 51 during the recent campaign against the French, but it was his previous experience as head of the RLM's Organisation Staff which made him the perfect man for the present post.

Prior to Kammhuber's assuming overall control, Falck had been doing the best he could with the limited means at his disposal. His aircraft, totally lacking any specialised radio equipment and even such basics as flame exhaust dampers, were simply standard Bf 110 day Zerstörer painted overall matt black. The complete absence of a ground control system also meant that Falck had to devise his own method of operational deployment. He managed to get a regiment of searchlights detached from those concentrated in the immediate vicinity of the Ruhr and had it moved forward up into Westphalia, to the northwest of Münster, astride the RAF bombers' main approach route. The Bf 110s of I./NJG 1 were stationed at Bönninghardt, behind this 'light belt', as Falck termed it (III. Gruppe was still at Cologne-Ostheim converting from its Bf 109Ds).

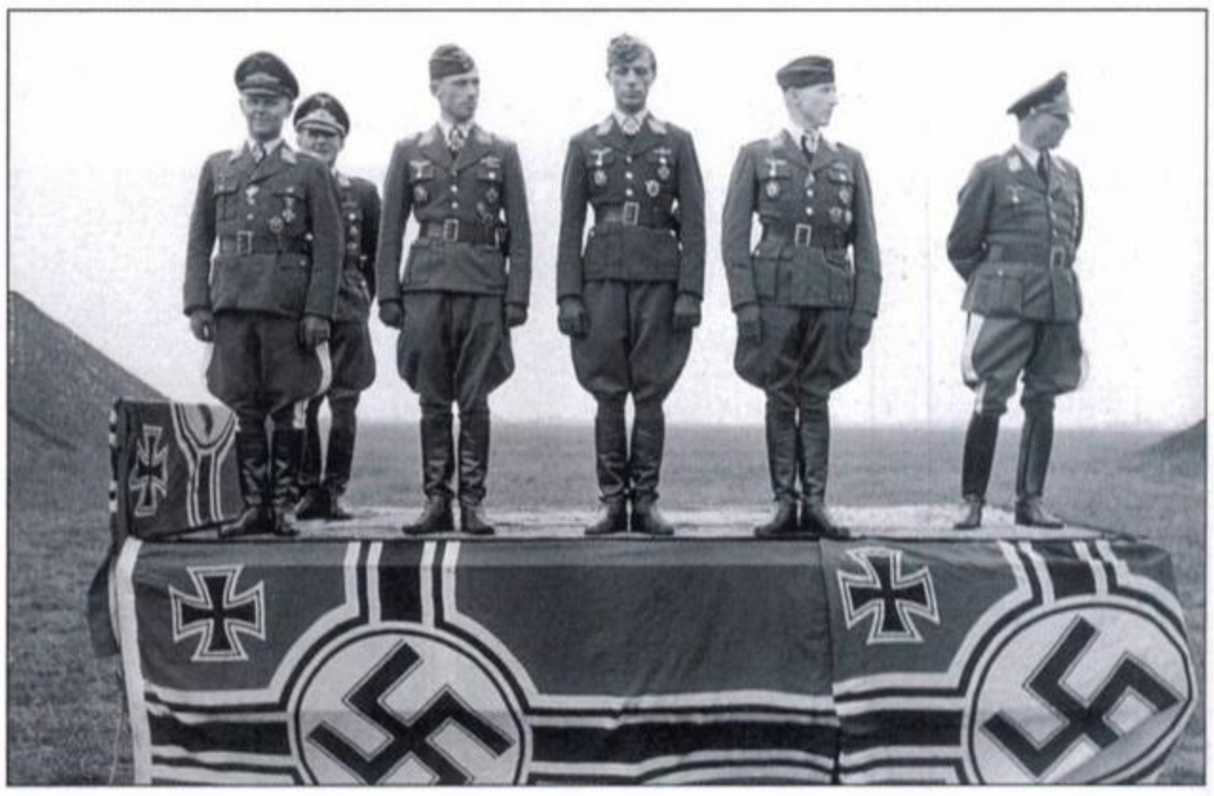
Warning of incoming bombers picked up by the Freya coastal radar stations would be relayed to I./NJG 1 by the codeword 'Fasan' ('pheasant'), whereupon Radusch's pilots would take off and loiter above a radio beacon to the rear of the searchlights. Sometimes they could lie in wait for as long as three hours. As soon as the agitated movement of the beams indicated the presence of an enemy bomber in the 'light belt', the night-fighter was free to launch an attack. The approach had to be made at high speed – in three minutes the bomber would have traversed the 'light belt' and reached the safety of darkness on the far side. It took a lot of practice not to overshoot the target. Many interceptions failed, particularly as the searchlights tended all too often to wander about in a seemingly aimless manner.

Success was finally achieved in the early

Hauptmann Walter Ehle, commander of II./NJG 1 from October 1940 to November 1943 (left), stands with his radio-operator Oberfeldwebel Weng. Ehle appears to be wearing an RAF-type Irwin jacket.



Above: Ground crew service the four 7.9-mm MG 17 machine-guns of a Bf 110. While the aircrews slept off the exertions of the night before, the ground crews cleaned the guns, re-armed and refuelled their charges in readiness for darkness and the next onslaught by the British bombers. As the war went on, the night-fighters became increasingly vulnerable to fighter-bomber attack.



Right: Some of the earliest successful night-fighter pilots line up in their finery for an award presentation. From left in the front row are Generalmajor Josef Kammhuber, Hauptmann Helmut Lent, Oberleutnant Paul Gilder and Hauptmann Helmut Bekker.

hours of 20 July when 2. Staffel's Oberleutnant Streib claimed a Wellington over Münster (although Streib's victim was almost certainly a No. 51 Squadron Whitley, P5007, which crashed some 35 km/22 miles NNE of the Westphalian capital). Forty-eight hours later Streib brought down a second Dishforth-based Whitley, No. 78 Squadron's N1487. It appeared that Falck's early version of *helle Nachtjagd* – 'light night-fighting', i.e., using aircraft in conjunction with searchlights – was beginning to pay off.

Like divisional commander Kammhuber, Falck's strengths were his qualities of leadership and his ability to organise. Although he flew numerous missions during his two-year tenure of office as Kommodore of NJG 1, Falck did not add a single kill to the seven he had scored as a Zerstörer pilot. The glory and the amassing of victories he left to his juniors. Foremost among these was Werner Streib, whose glittering operational career had netted him 65 nocturnal kills by the time he was promoted to Inspekteur der Nachtjäger (Inspector of Night-Fighters) for the final 14 months of the war.

Three other pilots of I./NJG 1 claimed victories before July was out; the Gruppe lost two Bf 110s to enemy action in the same period. By now, however, RAF bomber crews were becoming wise to the isolated barrier of searchlights just inside the German border 'where the flak never fired', and began simply to detour around it. Falck's somewhat desperate response to this was to detach individual batteries from his one searchlight regiment and hurriedly relocate them in those areas over which the bombers had passed the night before. Not only did this meet with a predictable and total lack of success – a full month passed before the next kill was claimed, again by the redoubtable Streib – it also made the Nachtjäger something of a laughing-stock throughout the Luftwaffe. One of the less barbed (and more printable) comments going the rounds likened Falck's pilots to 'night-watchmen chasing yesterday's bomb craters'.

The only solution was to extend the line of forward defences, exactly what Kammhuber proceeded to do, and within a year his Division controlled six searchlight regiments. Falck's original 'light belt' was not merely lengthened; more importantly, it was reorganised into a chain of interlocking 'boxes', each with its own ground-control radar system. Eventually, the 'Kammhuber Line' formed an unbroken barrier from the Skagerak in the north to below Paris in the south.

Carrying the fight to the enemy

While two-thirds of Falck's fighter strength was readying itself to defend the Homeland, the other third had been preparing to take the fight to the enemy's shores.

II./NJG 1 had been intended as a long-range intruder Gruppe from the outset. It was formed around a Zerstörerstaffel set up earlier by KG 30 for Norwegian coastal convoy escort duties out of Trondheim and Stavanger. Towards the close of the campaign in Norway, Staffelkapitän Oberleutnant Herbert Bönsch led the Ju 88s of his Z./KG 30 down to Ludwigslust to train for the new role, which was aimed at "attacking the enemy's bombers over their own bases, disrupting the RAF's night-flying training, and dropping a few small bombs".

At the beginning of July 1940 Bönsch's Staffel took up residence at Düsseldorf under its new designation of 4./NJG 1. It was joined there by 5./NJG 1, a newly activated Do 17-equipped Staffel, whose first Kapitän, Oberleutnant Schütze, was severely wounded on 19 July (after which command passed to Oberleutnant Jung). Operations commenced with just these two Staffeln, and were initially beset by teething troubles.

As Düsseldorf was considered too close to the Ruhr flak zones, it had been decided that the crews should use Schiphol in the Netherlands as a forward base. They would make the short hop across from Düsseldorf in the early evening, fly their missions from Schiphol, return there for a few hours sleep, and then make their way back to Düsseldorf by noon the following day. This routine had certain undeniable attractions. Landing after a mission, crews would be met at Schiphol by KLM-liveried chauffeurs, who would whisk them by limousine to their overnight quarters in Amsterdam in the luxurious Hotel Krasnapolski (post-war, the five-star Grand) where the crews, still in full flying gear, would be ushered through the revolving doors and shown to their rooms by frock-coated staff!

Although the aircrew revelled in the experience, the schedule was punishing on them, on the ground crews, and on the aircraft. Moreover, it was not producing the desired results. Falck and Kammhuber flew to Düsseldorf to assess the situation. They met

Two new Knight's Cross recipients, Leutnant Hans Hahn of I./NJG 2 (left) and Generalmajor Josef Kammhuber, proudly pose for the camera. Their awards were given on 9 July 1941.

The first 10 Nachtjagd Knight's Crosses

Name	Award date	Later awards	Score (day/night)	Fate
Major Wolfgang Falck	1 October 1940	-	7/0	Survived war
Oblt Werner Streib	6 October 1940	Oak Leaves/Swords	1/65	Survived war
Ofw. Paul Gildner	9 July 1941	Oak Leaves*	4/44	KAS* 24 February 1943
Leutnant Hans Hahn	9 July 1941	-	0/10	KIA 11 October 1941
GenMaj Josef Kammhuber	9 July 1941	-	0/0	Survived war
Oblt Reinhard Eckhardt	30 August 1941	-	3/19	KIA 30 July 1942
Oblt Helmut Lent	30 August 1941	Oak Leaves/Swords/ Diamonds	8/102	KAS 5 October 1944
Ofw. Wilhelm Beier	11 October 1941	-	0/36	Survived war
Oblt Egmont Prinz zur Lippe-Weissenfeld	16 April 1942	Oak Leaves	0/51	KAS 12 March 1944

(*) posthumous/ (KAS) killed on active service/ (KIA) killed in action

Do 17Z

Helmut Lent, who became the second-ranking night ace, flew this Lichtenstein-equipped Do 215B-5 Kauz III with I./NJG 2 from Leeuwarden in 1942. The Kauz (screech owl) designation identified aircraft with the 'Spanner' IR sight.

with the crews of 4. and 5. Staffeln in the base's rustically decorated officer's mess. At first diffident, the assembled flyers were soon voicing their doubts and describing their problems in no uncertain terms. Kammhuber closed the discussion in an equally forthright manner:

"Ja, meine Herren, I gather from your reports that you are experiencing nothing but difficulties. But please spare me the old stories of trying to swat flies in a darkened room. We have a very specific and important task to fulfil.

"Don't come to me questioning these plans because you are having to contend with a lack of visibility and problems of orientation. I don't want to hear any more of why they won't work, I want to hear how they can be made to work!

"Your Gruppe is the one which has been chosen to fly to England at night to tackle the problem at its roots by finding and destroying the enemy before he comes over here.

"This has got to work – and it will work!"

Kammhuber's exhortations seem to have had some effect. Two pilots of 5./NJG 1, Feldwebels Wiese and Schramm, each reported the destruction of a Wellington over the North Sea, some 100 km (62 miles) off the Dutch island of Texel, late on the evening of 23 July. There are, however, no comparable recorded RAF losses to substantiate this. The two kills which were claimed the following month, both Hurricanes over the east coast of England – one at 23.00 on 17 August near Lowestoft, the other 10 nights later over Grimsby – appear equally dubious, as do the Staffel's September 'victims', a brace of Blenheims reportedly shot down 48 hours apart over Waddington (although it should be pointed out that on the first of the two dates in question, 8 September, three Blenheims were lost without trace on cross-Channel operations).

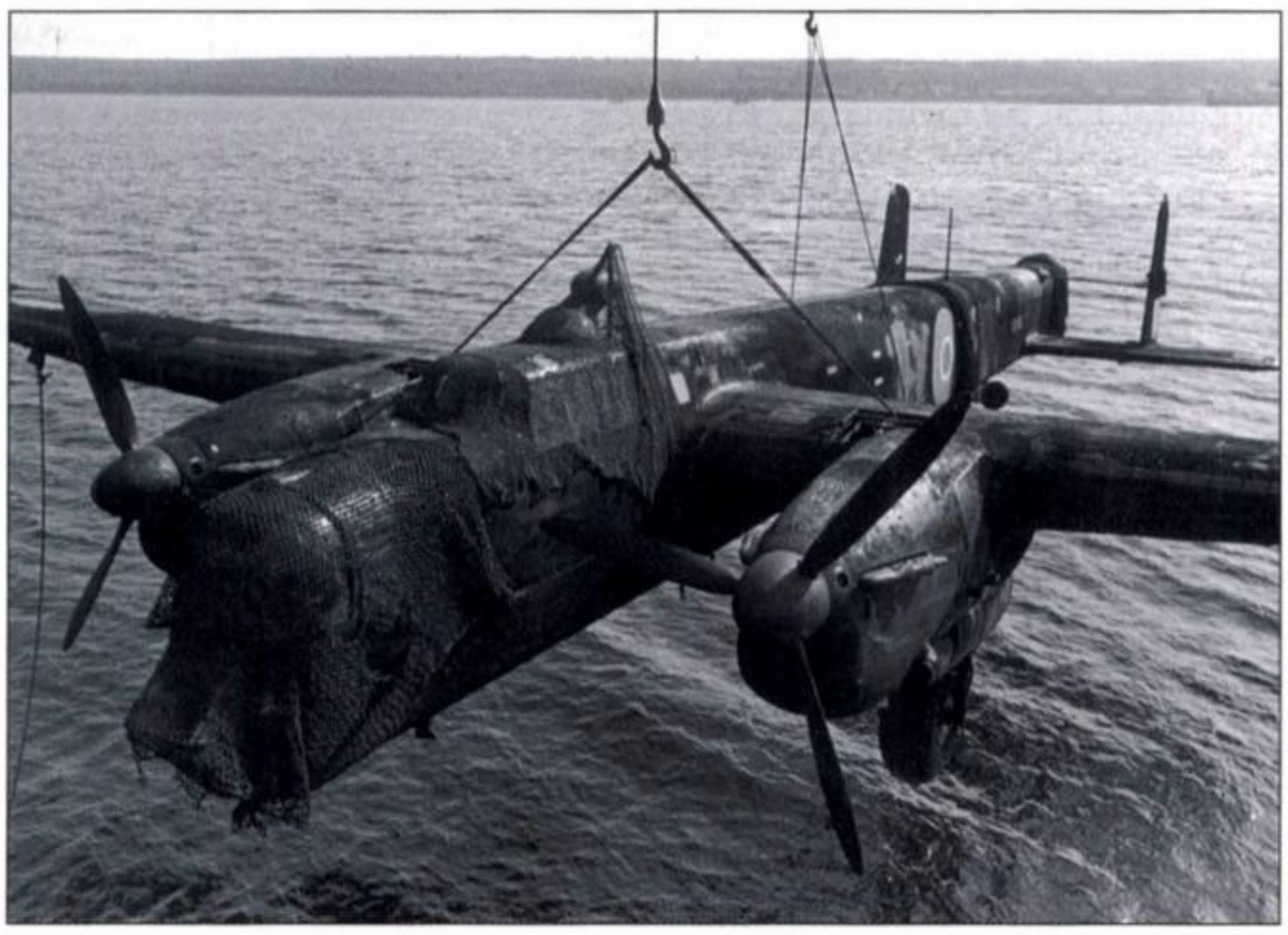
It could be argued that these early weeks had produced no results whatsoever. Against this the Staffeln had lost three aircraft (two Ju 88C-2s and one Do 17Z-10) in crashes over the continent. They had also suffered their first combat fatalities when a Blenheim night-fighter of No. 29 Squadron shot Oberfeldwebel Fritz Zenkel's Ju 88 ('4D+GZ') into the sea off Spurn Head in the early hours of 18 August, with the loss of all three crew members.

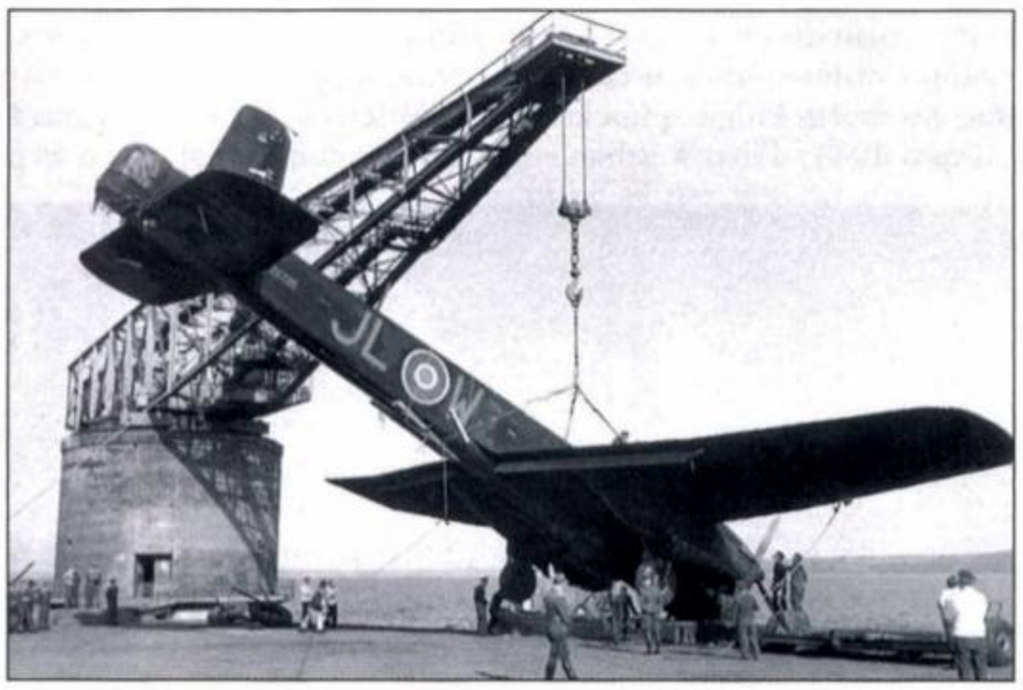
In September everything was to change. A 6. Staffel had been formed under Hauptmann Karl Hülshoff to bring II./NJG 1 up to full complement, command of the Gruppe being given to Major Karl-Heinrich Heyse. The unit forsook its daily shuttle between Düsseldorf and Schiphol (and with it the Krasnapolski's snow-white feather beds) to take up permanent residence in the Netherlands at Gilze-Rijen. Lastly, it was decided to redesignate II./NJG 1 and to make it the first Gruppe of a planned all-intruder Geschwader. Henceforth, Heyse's unit would operate as I./NJG 2.

The change of designation brought about a change in fortunes, too. The Hampden claimed by Hauptmann Hülshoff over Dishforth on 20 October appears on no post-war list of losses. Four nights later the 'Wellington' attacked at Linton-on-Ouse by one of his 3. Staffel pilots, Feldwebel Hahn – which was undoubtedly the No. 102 Squadron Whitley shot down in flames while taking off from the Yorkshire base on that date – finally gave the intruders their first confirmed success. The two Blenheims claimed near Hemswell an hour earlier on that same evening of 24 October by 1./NJG 2's Oberleutnant Kurt Herrmann were, almost equally certainly, a Blenheim and a Beaufort, both of which landed safely but battle-damaged at Docking. On 28 October Leutnant Heinz Völker correctly identified a Hampden he shot down near Scampton (the No. 49 Squadron bomber, X3027, crashed into the sea just off Skegness).

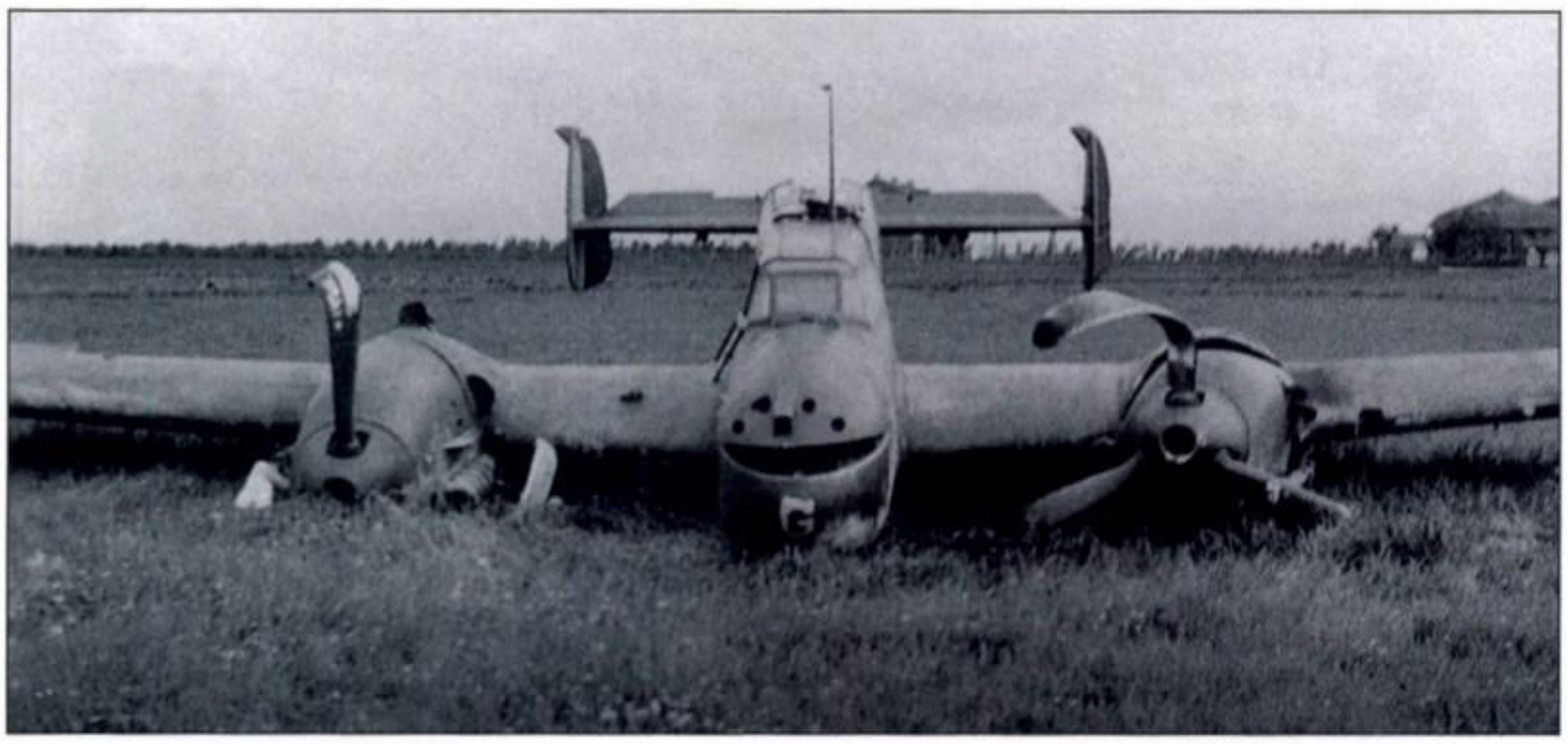
I./NJG 2 was beginning to pay a price for its intruder missions over eastern England. Before the year was out, four of its Junkers were reported missing, presumed to have crashed into the North Sea. One of the four was the Gruppenkommandeur's 'R4+BB', which failed to return from a sortie on the night of 23/24 November. Major Heyse was immediately replaced by Hauptmann Karl Hülshoff, who had also been aloft that night, claiming a second (unconfirmed) kill. A month later, on the morning of 21 December, Hülshoff's successor as Staffelkapitän of 3./NJG 2, Oberleutnant Ulrich Meyer, was brought down by the anti-aircraft defences of RAF Manby in Lincolnshire. Having opted – either unwittingly or unwisely – to attack the home of two RAF armament schools, Meyer and his crew were the first of I./NJG 2's losses to be directly attributable to enemy action.

Reinforced by the addition of a 4. Staffel (formed from Stab I./ZG 2), the Gruppe's activities increased in 1941. Soon it was making its presence felt all along the United Kingdom's eastern counties, targeting not only operational Bomber Command bases, but also the RAF's nocturnal training programmes. Given the numbers and variety of aircraft going about their anonymous business over the blacked-out





Armstrong Whitworth's Whitley was a common victim of the night-fighters in the 1939-42 period. This aircraft, Z6795 of No. 10 OTU based at Abingdon, is, however, a bit of a mystery. Seen here – with no visible damage and its guns removed – being lifted onto a dock by German personnel, it was recorded as missing off Cornwall on 22 September 1942. Despite being a training unit, No. 10 OTU lost 39 Whitleys on operations during 1942.



Left and below left: Two views of a Bf 110F of II./NJG 1 which crash-landed near St Trond having been struck by return fire from a Wellington taking part in the first '1,000-Bomber' raid on Cologne on 31 May 1942. The Messerschmitt, flown by Leutnant Niklas and Unteroffizier Wenning, destroyed the bomber and one other that night – the crew's first victories.

English countryside, it is perhaps understandable that the crews of the predatory Ju 88s continued to experience difficulties in identifying their victims.

With the hindsight of post-war research, however, it is sometimes possible to match claim to loss (or, more often, near escape – for I./NJG 2 still regularly overestimated its actual number of kills). Thus, for example, Oberleutnant Albert Schulz's first two victories, claimed as a pair of Blenheims brought down 15 minutes apart near Church Fenton in the early hours of 16 January 1941, translate into a brace of OTU Defiants which crash-landed with their occupants safe. Feldwebel Hahn came slightly nearer to the mark when he shot down a heavily laden No. 207 Squadron Manchester shortly after it had taken off from Waddington on the evening of 13 March. Hahn must have momentarily glimpsed the victim's distinctive twin tail unit, for he logged this, his fourth kill, as a Lockheed Hudson.

April 1941, when it achieved at least 10 confirmed victories, was to prove the Gruppe's most successful month over England. Yet another case of misidentification, late on 8 April, might have altered the course of RAF history. 3. Staffel's Feldwebel Hahn (again!) reported the destruction of a Wellington when he returned to Gilze-Rijen in the early hours of the following morning. The aircraft he had engaged as it was landing at Wellingtore in Lincolnshire had, in reality, been a Beaufighter of No. 29 Squadron returning from a fruitless night-fighter patrol over Manchester. The machine swerved off the runway and hit some trees. The pilot, who was killed later in the war, described the incident in his memoirs, which were published posthumously in 1946:

"...we were circling (to land) looking forward to bacon and eggs and coffee. I called up the control and asked them if there were enemy aircraft about.

"No, there were no enemy aircraft, they said.

"This was fine. So I turned on my navigation lights and began the approach. Down went the wheels and flaps according to plan. Meanwhile, down on the ground watching events, but unable to do anything because there were no RT facilities, stood Charles Widdows (the squadron CO). He had been looking at a suspicious aeroplane, which had been floating around for some time. Now he saw it get into position behind my tail. When about 50 ft off the ground the Junkers 88 let me have it. But he too was a bad shot and all we did was to crash through some trees on the far side of the 'drome, although one cannon shell went into the radio operator's leg and wounded him."

The Beaufighter pilot, one Flight Lieutenant Guy Gibson, later returned to bombers and gained fame as leader of the now legendary 'Dam Busters'.

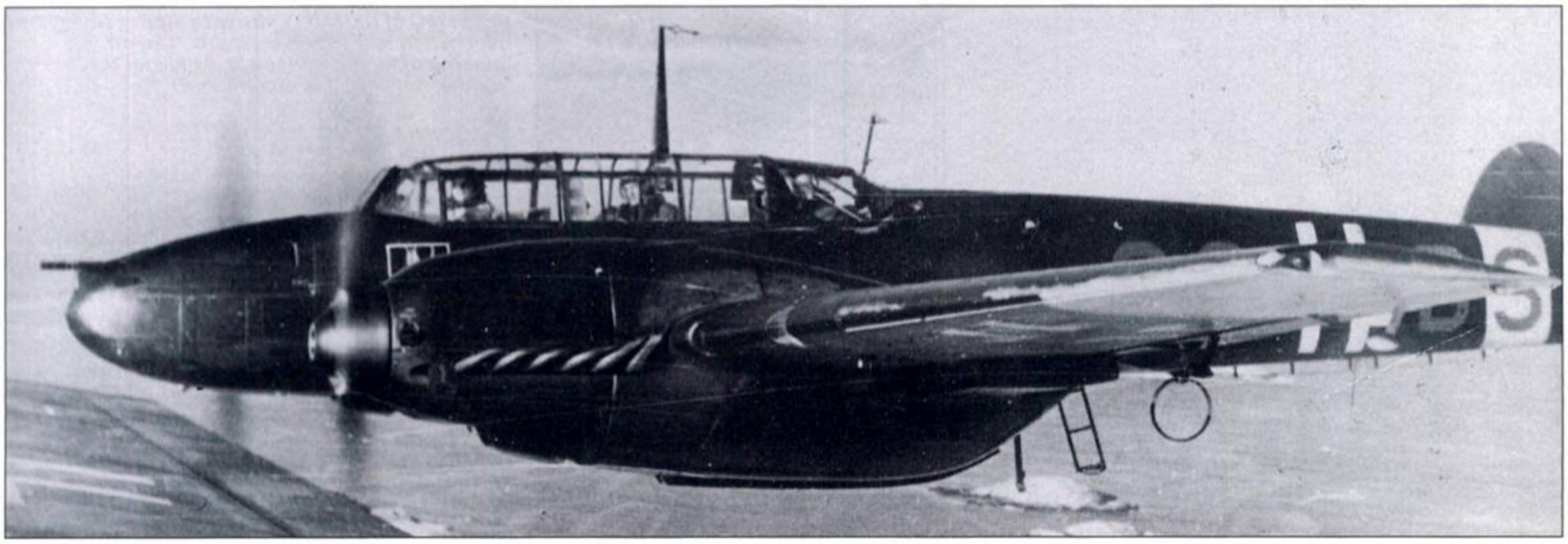
The indefatigable Hans Hahn, promoted to Oberfeldwebel on the strength of his recent exploits, was also involved in at least one of the four possible losses attributable to the intruders in May (it should be borne in mind that the night Blitz was currently approaching its climax and I./NJG 2's Junkers were by no means the only Luftwaffe aircraft abroad over England during the hours of darkness in the spring of 1941). Hahn shot down a single-engined fighter south of Norwich in the early hours of 4 May and claimed it – somewhat imaginatively, it must be said – as a Fairey Fulmar! This could only have been the No. 222 Squadron Spitfire lost at that time (almost to the minute) some 20 km (12 miles) away on the other side of the city.

Seven kills in July

After a quiet June, July brought a resurgence of activity in which seven RAF aircraft were downed. Most, if not all, would have been victims of the intruders – the bulk of the Luftwaffe's bomber force was busy elsewhere by this time, the invasion of the Soviet Union having been launched on 22 June – but few can be identified with any degree of certainty. Oberfeldwebel Laufs's 'single-engined aircraft' of 5 July was very likely another Spitfire, a No. 452 Squadron machine shot down while approaching to land at North Coates. And a Blenheim and a Whitley claimed on 28 and 30 May, respectively, were probably a pair of Oxfords lost on those dates. The identity of the party responsible for shooting the tail off an inoffensive Tiger Moth of No. 2 EFTS over Cambridgeshire in the middle of the month remains a mystery.

August's five RAF losses to known enemy action were all Wellingtons, as was one of September's two, the other being an OTU Hampden. On 3 October future Knight's Cross

One of the ex-Zerstörer pilots that made a successful transition to night-fighting was Wilhem Herget, seen later in the war. Herget was known as 'der Kleine' (the Little One) and needed blocks fitted to the rudder pedals of his Bf 110 so that he could reach them. After scoring 15 Zerstörer victories, he was credited with 57 night kills and one on the Me 262 while flying with JV 44.



Above: The three crew members (pilot, radio-operator and gunner) of this NJG 1 Bf 110F can be seen clearly. The Bf 110, which began as a two-seater, was carrying four crew and many hundreds of kilos of radar equipment in its final versions in service in 1945.

Right: The armament of the Bf 110 grew from two cannon and two forward-firing and one defensive machine-guns, as seen on this BF110F, to as many as six forward-firing cannon, and a pair in an upward-firing 'schräge Musik' installation or a pair of rear-firing machine-guns.

recipient Feldwebel Alfons Köster of 3./NJG 2 claimed his 11th victim in six months over England, and the Gruppe's only four-engined kill of the intruder campaign, when he brought down Stirling N6085 (MG-H) of No. 7 Squadron shortly after it had lifted off from Oakington to bomb Brest.

Just over a week later, British and German records for the period close on a totally incompatible note. On the evening of 12 October the RAF lost an OTU Blenheim shot down over Buckinghamshire. The following night I./NJG ended its assault on the United Kingdom by reportedly destroying a Flying Fortress over Cambridgeshire.

Irreconcilable claims

Between January and October 1941 I./NJG 2 had claimed no fewer than 123 enemy aircraft destroyed. The actual figure is believed to be exactly one-third of that number: 23 operational aircraft (bombers and fighters) and 18 training and school machines. Against this it had suffered the loss of 22 of its own number, plus many others written-off or damaged. Of the former, seven simply failed to return and are presumed to have crashed into the North Sea. A similar total fell victim to RAF night-fighters (including one to Guy Gibson's CO, Wing Commander S. C. Widdows). Three others came down over England: one force-landed in Norfolk after engine failure (and was promptly whisked off to Farnborough for examination), one flew into high ground over the Yorkshire moors, and the third crashed in flames in Essex.

Perhaps the most unusual of the Gruppe's losses was that of the Ju 88C-2 ('R4+GM') flown by the Staffelkapitän of 4./NJG 2, Oberleutnant Paul Bohn. Hit by return fire from a bomber (variously identified as a Wellington or a Whitley) during an encounter over the North Sea shortly after midnight on 26 June, Bohn was mortally wounded. Flight engineer Unteroffizier Walter Lindner managed to pilot the Junkers back to northern France where – after attaching a static line to Bohn's parachute and pushing his lifeless form out of the aircraft – he and the radio-operator themselves baled out. The Ju 88 flew the length of France, and across the Alps, before finally running out of fuel and crashing near Milan in northern Italy.

Of the remaining four aircraft lost, two are believed to have been shot down in error by fellow intruders and two are known to have collided with RAF machines. 3. Staffel's Leutnant Heinz Völker and his crew in 'R4+BL' perished together with all eight occupants of a No. 11 OTU Wellington when their two aircraft were involved in a mid-air collision near Baldock, Herfordshire in the early hours of 22 July. On the evening of 11 October an Oxford of No. 12 FTS was struck over Lancashire by Ju 88C-4 'R4+NL' piloted by newly-commissioned Leutnant Hans Hahn. Again, all those involved lost their lives.

The demise of Hans Hahn, who had been awarded the Knight's Cross on 9 July as the first intruder pilot to claim 10 victories, effectively wrote *finis* to I./NJG 2's campaign over England. (Ironically, the Gruppe's second Knight's Cross went to Oberfeldwebel Wilhelm Beier – its highest scorer with 14 kills claimed – on the very day Hahn was killed.) Shortly thereafter orders were received from the Führer himself that night intruder sorties against England were to cease forthwith. Despite General Kammhuber stressing the value of such operations, and urging that they should be allowed to continue, Hitler was adamant. He simply did not believe the successes being claimed (which at this time outstripped those of all other Nachtjagdgruppen put together). Where was the proof? Besides, the ordinary German citizen was not interested in how many enemy aircraft had not attacked his town last night. What he wanted to see was tangible evidence – preferably in the form of a pile of smoking wreckage close by – that the Terrorflieger who had bombed his house had paid the price.

Although perhaps psychologically sound, Hitler's decision was a major strategic blunder. RAF Bomber Command would remain virtually unmolested and free from attack over its home territory for the rest of the war. The Ju 88s of I./NJG 2, meanwhile, commanded now by Hauptmann Erich Jung, had been transferred to

A Bf 110C of III./NJG.1 sits with starter trolley plugged in ready for a scramble take-off. A number of kill markings are visible on the rudder, but the pilot is unknown.

Catania in Sicily for operations against Malta and convoy escort duties in the Mediterranean.

The Kammhuber Line

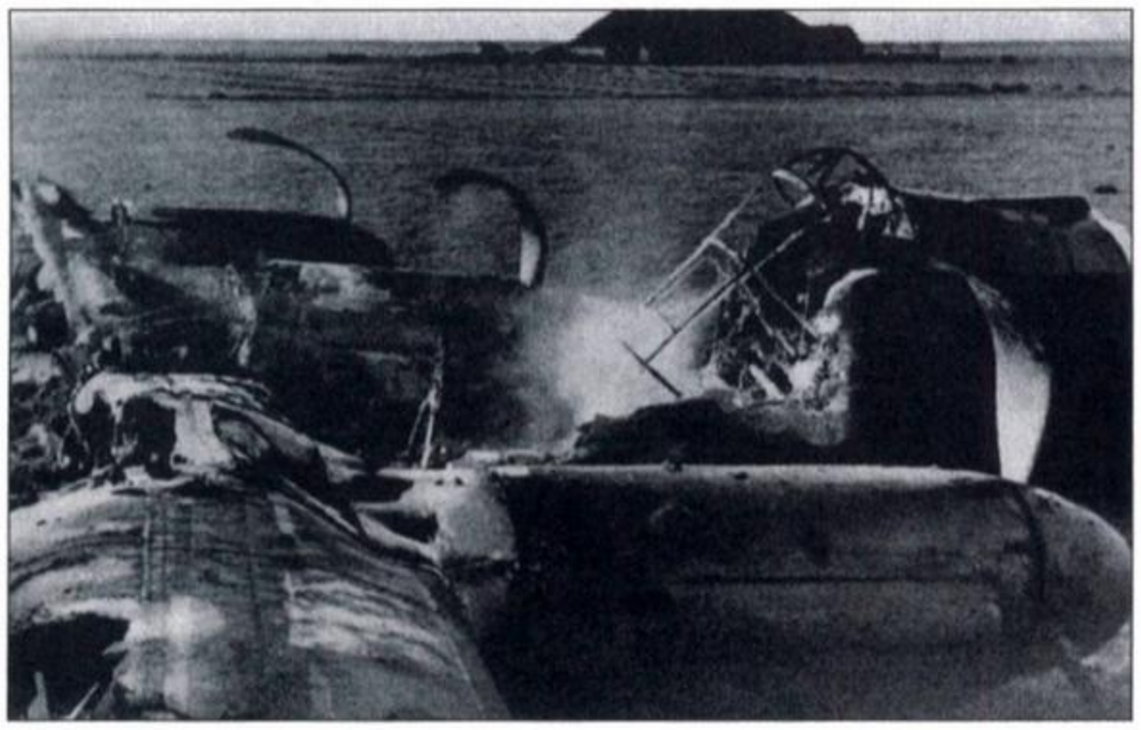
The Luftwaffe's night-fighter arm had, at a stroke, been deprived of its sole, overwater, offensive capability. However, the development of the defensive belt along its own, and neighbouring, North Sea shorelines continued apace, both in terms of new Gruppen activated and in attempts to establish an effective ground control system.

Firstly, the new Gruppen: the redesignation of the intruder unit from II./NJG 1 to I./NJG 2 in September 1940 had meant that yet another new II./NJG 1 had then to be created (the third in as many months). The timing was opportune. Those crews who had preferred not to remuster as night-fighters but who had, instead, elected to remain with the day Zerstörer, had received a severe and unexpected mauling over England. The ludicrous situation had arisen wherein the long-range escort fighters themselves had to be provided with a fighter escort! By the latter part of the Battle of Britain, the Luftwaffe found itself with a pool of semi-redundant Zerstörer on its hands. The Bf 110, though, was far from unemployable: Falck's earlier experiments had shown that it offered great potential as a night-fighter. It was almost inevitable that, over the coming months, one Zerstörergruppe after another would disappear from the day inventory as its members were retrained and redesignated to swell the growing ranks of the Nachtjagdwaffe.

One of the most underemployed of all the Battle of Britain Zerstörergruppen was the Norway-based I./ZG 76, whose one major foray across the North Sea against northeastern England had been a near disaster. This Gruppe was to become the new II./NJG 1. Early in September Kommandeur Hauptmann Graf von Stillfried's unit was transferred from Stavanger to Ingolstadt, in Bavaria, for night-fighter training. By 2 October 1940 it was established at Arnhem-Deelen as II. Gruppe of NJG 1. Falck decided to provide the newcomers with a core of experienced personnel by ordering its 4. Staffel to change places with Oberleutnant Walter Ehle's 3./NJG 1. When Hauptmann Graf von Stillfried was killed in a crash on 6 October, Ehle was promoted to the command of II./NJG 1 (which he was to lead with great success for over three years until his own death on 17 November 1943).

Another new Gruppe created in October 1940 was I./NJG 3, likewise formed from an ex-Zerstörer unit – the heavy-fighter wing of Lehrgeschwader 1. As V.(Z)/LG 1, this Gruppe had enjoyed considerable success over Poland and France, but had then suffered devastating losses during the Battle of Britain. Hauptmann Günther Radusch was transferred from the command of I./NJG 1 to take over the new

Below and below right: The debut of the Avro Lancaster in early 1942 marked the escalation of the night air war. This much-photographed example, brought down over Holland or northern Germany, was one of the first to fall victim to the night-fighters.



The Nachtjagd's first 20 kills

PILOT	UNIT	CLAIM	POSSIBLE VICTIM	DATE/TIME	LOCATION
Fw. Förster	8./NJG 1	Whitley	Whitley Mk V N1496, No. 10 Sqn	9 Jul 40/02.50	off Heligoland
Oblt Streib	2./NJG 1	Wellington	Whitley Mk V P5007, No. 51 Sqn	20 Jul 40/02.00	Munster
Oblt Ehle	3./NJG 1	Wellington	Wellington Mk IC R3165, No. 75 Sqn	21 Jul 40/01.40	Munster
Oblt Wandam	Stab I./NJG 1	Wellington	Wellington Mk IC R3210, No. 37 Sqn	21 Jul 40/02.27	Borken
Oblt Streib	2./NJG 1	Whitley	Whitley Mk V N1487, No. 78 Sqn	22 Jul 40/02.00	Munster
Fw. Wiese	5./NJG 1	Wellington	Blenheim Mk IV R3748, No. 110 Sqn	23 Jul 40/22.30	North Sea (Intruder mission)
Fw. Schramm	5./NJG 1	Wellington	as (6.) above	23 Jul 40/22.30	North Sea (Intruder mission)
Lt. Pack	3./NJG 1	Wellington	Wellington Mk IC P9275, No. 99 Sqn	26 Jul 40/01.14	Coesfeld
Ofw. Lauffs	4./NJG 1	Hurricane	unconfirmed	17 Aug 40/23.00	England (Intruder mission)
Ofw. Merbach	Stab I I./NJG 1	Hurricane	unconfirmed	27 Aug 40/21.30	England (Intruder mission)
Oblt Streib	2./NJG 1	Wellington	Wellington Mk IC T2559, No. 214 Sqn	30 Aug 40/23.24	Emmerich
Oblt Streib	2./ NJG 1	Whitley	prob. Hampden Mk I L4079, No. 50 Sqn	31 Aug 40/00.30	Arnhem
Fw. Gildner	3./NJG 1	Whitley	prob. Hampden Mk I P4370, No. 144 Sqn	3 Sep 40/00.45	Sittard
Lt Herman	4./NJG 1	Wellington	unconfirmed	8 Sep 40/23.00	England (Intruder mission)
Fw. Sommer	5./NJG 1	Blenheim	unconfirmed	10 Sep 40/23.15	England (Intruder mission)
Fw. Gildner	3./NJG 1	Hampden	Whitley Mk V P5008, No. 58 Sqn	18 Sep 40/22.30	Groenlo
Fw. Gildner	3./NJG 1	Hampden	Whitley Mk V N1425, No. 77 Sqn	19 Sep 40/00.28	Ziuwent
Oblt Griese	1./NJG 1	Wellington	prob. Wellington Mk IC R3150, No. 37 Sqn	30 Sep 40/00.34	Bramsche
Oblt Streib	2./NJG 1	Wellington	Wellington IC R3292 or T2549, No. 115 Sqn	30 Sep 40/22.49	Bersenbrück
Oblt Streib	2./NJG 1	'Handley Page'	as (19.) above	30 Sep 40/23.19	Badbergen

Future ace Oberfeldwebel Paul Gildner and his crewman, Unteroffizier Muller, of NJG 1 inspect the wreckage of a Wellington they claimed over Holland on 13 March 1941. This may be N2746 of No. 214 Squadron, which fell near Groningen with the loss of five of the six crew.

Gruppe upon its redesignation as I./NJG 3. Initially it made little contribution to the build-up of Kammhuber's defences. For almost a year, 1. and 2. Staffeln were to be engaged primarily in training duties and practice flights from Vechta, Oldenburg and Wittmundhaven, while 3./NJG 3 had been promptly despatched to the Mediterranean.

There may have been a ready supply of Bf 110s and their crews available to increase the number of flying units, but the lack of an efficient method of ground control proved to be a much harder problem to resolve. Initially, Kammhuber's only electronic 'eyes' remained the coastal Freya radar stations, whose services Falck had first employed to forewarn his pilots of approaching enemy bombers. With a range of some 160 km (100 miles), the Freya was an undoubted early-warning asset, but it was totally unsuitable as an instrument for close fighter control. Not only did it lack detail definition (the two blips representing the target bomber and the attacking fighter merged on the screen long before the latter was in visual contact), but also – and most crucial of all – it was unable to indicate altitude.

In an attempt to overcome these drawbacks, a specialised signals unit, commanded by Leutnant Hermann Diehl, was set up on 7 September 1940 at Nunspeet, near Zwolle, south of the Zuider-Zee (Ijsselmeer). This was directly under one of the main approach routes used by the RAF's bombers. Here, the resourceful Diehl rigged a height finding attachment to the local Freya and carried out a series of experiments using a Ju 52 to simulate an incoming bomber.

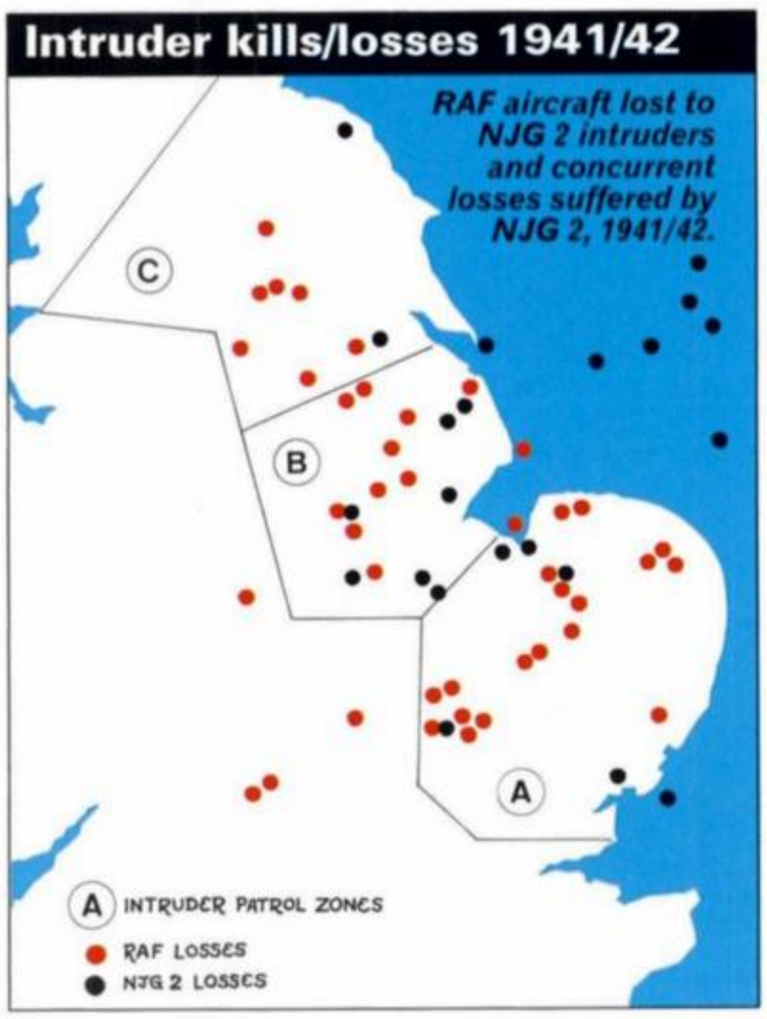
Operational trials began soon after. On the night of 16 October 1940 Leutnant Ludwig Becker of the experienced 4./NJG 1 (i.e., the erstwhile 3./NJG 1) scored the Luftwaffe's first ground-controlled night victory. Flying one of the Staffel's few Do 17Z-10 'Kauz' night-fighters, Becker was vectored on to the approaching bomber by Nunspeet control and closed to within 50 m (165 ft) before opening fire.

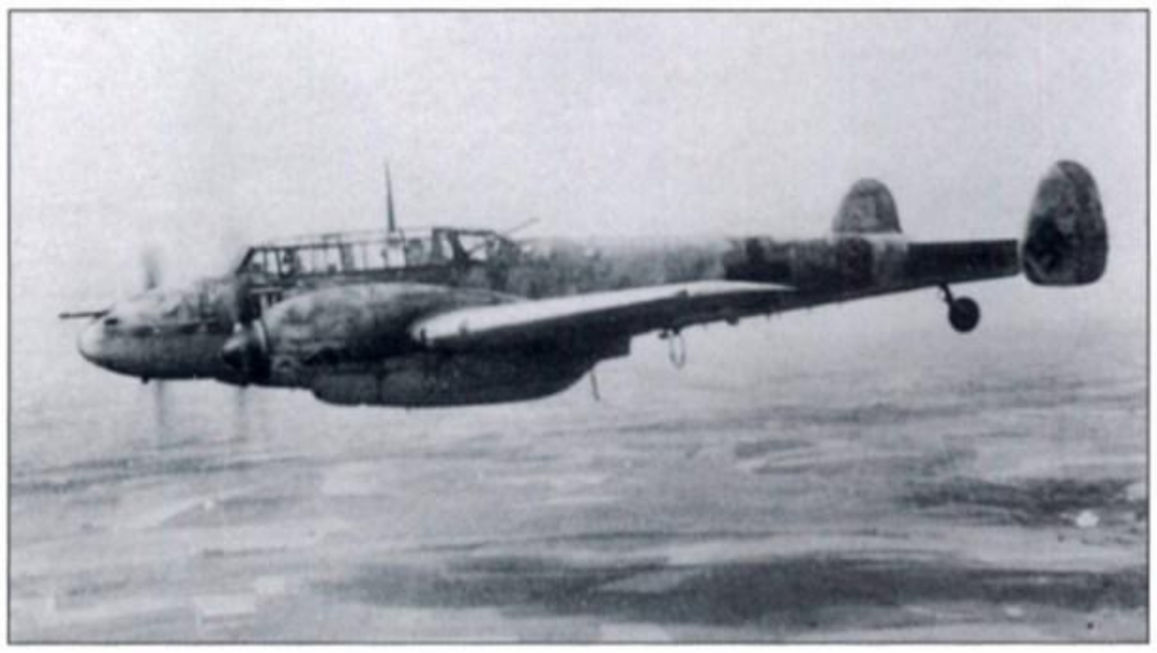
Becker: "I was in an ideal position, at the correct altitude of 3300 m [10,825 ft] and being directed towards the enemy by a continual string of corrections. Suddenly, in the moonlight, I saw an aircraft about 100 m [328 ft] above me to the left. I approached closer and recognised it as a Vickers Wellington. Slowly, I closed in from behind and aimed a 5-6-second burst at the fuselage and wingroot. The star-

Wolfgang Falck exits his Bf 110. Unlike most night-fighters, it carries an additional badge, that of his first command, 2./ZG 76, a ladybird on a shield. Also evident is the external armoured windscreen panel introduced with the Bf 110F-1 and fitted retrospectively to D and E models.

A crash-landed Ju 88C-4 sports a mud-spattered example of the* Englandblitz *badge. The location of this incident is unknown, but it represents the fate of many intruders flying against England in 1941. This view shows the main armament of three 7.9-mm MG 17 machine-guns and a 20-mm MG FF cannon, which was concentrated in the starboard side of the nose. Two more MG FF cannon were fitted in the ventral gondola.

This Wellington force-landed at II./NJG 1's base, St Trond, and burnt out, possibly at the hands of its crew. Morning revealed the wreckage on a taxi track.





Above: A Bf 110F-4a of 4./NJG 1 is seen jacked up for gun harmonisation. The letter 'N' on the cowl denoted the DB 601N engine which used higher (96-100) octane fuel. The supporting brace for the FuG 202 radar runs back to the forward bulkhead.

Left: As early as mid-1941, the overall black finish of night-fighters began to give way to grey mottled schemes, as seen on this Bf 110C-4 of NJG 4. Views of Bf 110s in these schemes and without radar are rare. Göring's dislike of "boxes with coils" helped delay the introduction of German airborne radar until February 1942.

board engine immediately caught fire. For a short while the Engländer continued to fly on, losing height rapidly. The fire appeared to die out. But then I saw him spin towards the ground and burst into flames on impact."

Becker's victim was undoubtedly No. 311 (Czech) Squadron's L7844 en route to Kiel. The Wellington crashed in Gelderland, some 30 km (19 miles) NNW of Apeldoorn. Its interception and destruction, although having taken place on a clear moonlit night of excellent visibility, was enough to convince Kammhuber of the possibility of 'dark' night-fighting – that is, of directing the night-fighter by ground-control alone, without the benefit of searchlight illumination.

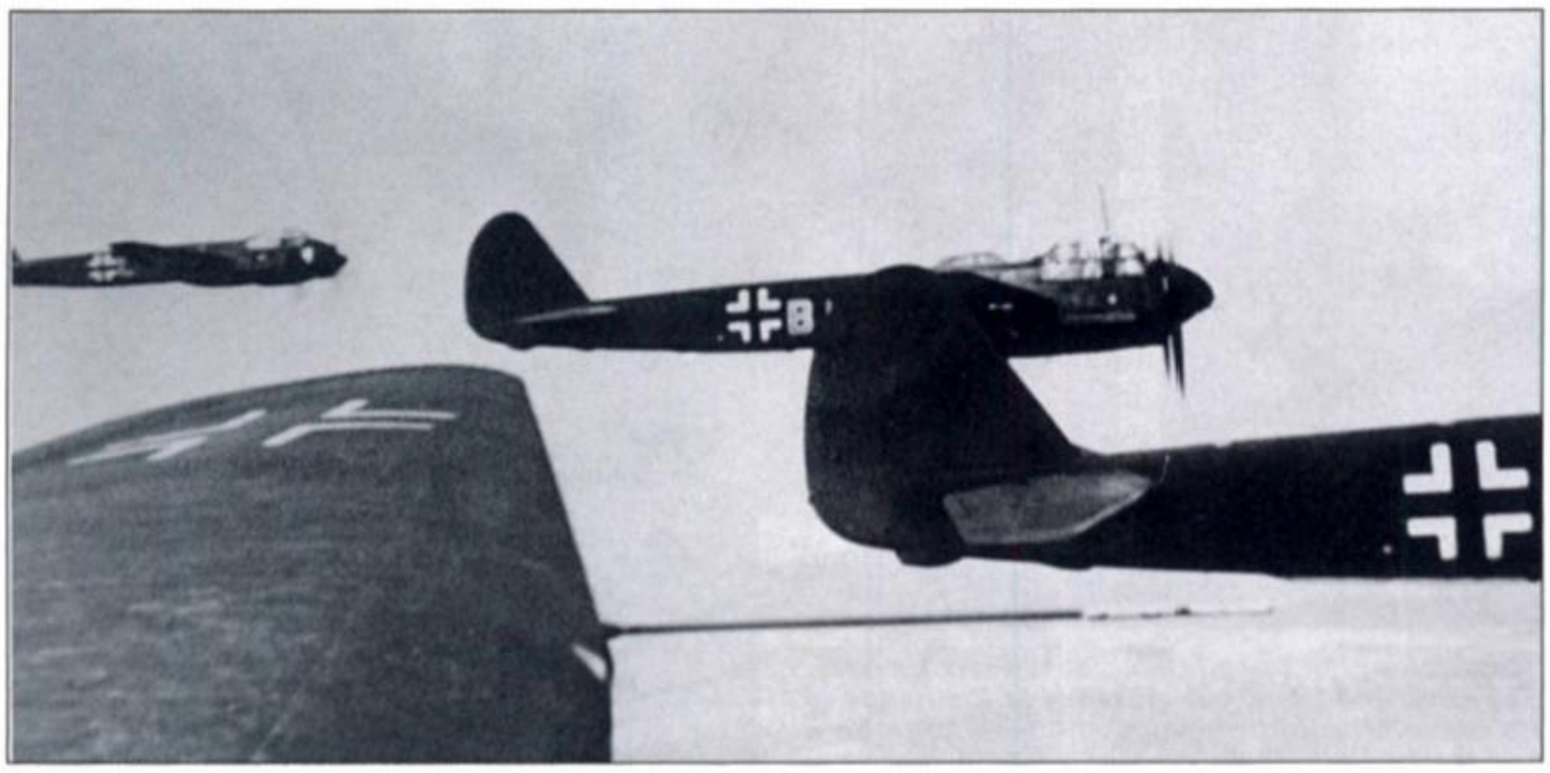
He extended Diehl's experimental Nunspeet installation into a series of overlapping stations covering the North Sea coastline from Denmark to the Channel. By the late summer of 1941 *dunkle Nachtjagd* interceptions had reportedly brought down some 50 RAF bombers – although *helle Nachtjagd* operations had accounted for almost double that number, and UK intruder operations had claimed nearly half as many again. (With its penchant for acronyms the Luftwaffe differentiated between 'dark' and 'light' night-flying operations by referring to them as 'Dunaja' (*dunkle Nachtjagd)* and 'Henaja' (*helle Nachtjagd*), respectively.) Eventually there would be 16 Dunaja zones forming the Luftwaffe's first line of nocturnal defence. Although its importance diminished with the advent of airborne radar early in 1942, the Freya was to remain a useful implement in the air battle over the Reich until the closing months of the war.

Meanwhile, with the approach of autumn and the onset of bad weather, Kammhuber was becoming concerned that his entire *helle Nachtjagd* programme would be thrown into disarray. Heavy cloud cover could play havoc with a system that relied solely on visual sighting. He had already tried coupling a searchlight to a Freya near Arnhem (a so-called 'parasite installation') to reduce the time the searchlight batteries spent probing the night sky for the target. It is claimed that a second such 'parasite', east of Zutphen in the Netherlands, was instrumental in homing Oberleutnant Griese of 2./NJG 1 on to the Wellington – of No. 115 Squadron – which he shot down over Löningen in the early hours of 1 October.

Würzburg-A radar

What the *helle Nachtjagd* belt of defences really required, however, was a purpose-built precision radar with a range of some 60 km (37 miles). Fortunately, just such an instrument was in the offing. The firm of Telefunken had already developed a small gun-laying radar, the Würzburg-A, for the flak regiments. Now they started to work on a larger model, replacing Würzburg-A's 3-m (9.8-ft) diameter solid dish with a lattice-work reflector measuring 7.5 m (24.6 ft) across. This, it was hoped, would narrow the radar beam sufficiently to give the required range.

As an interim measure, Kammhuber was allocated a few of the earlier Würzburg-A models to augment his *helle Nachtjagd* activities. Their introduction into service in October resulted in a reorganisation of Henaja operational procedure. It was not a success. Each Würzburg-A was positioned among the line of sound locators in front of the searchlights. Although the night-fighters were still based behind the searchlights, they were now ordered to circle a beacon within the illuminated zone. As soon as the Würzburg-A picked up an approaching target, the night-fighter was vectored out into the darkness ahead of the



NJG 2 flew many night intruder missions over the UK in 1940-41 from bases in Holland, with Ju 88Cs such as these. Ju 88C-0, C-1 and C-2 variants were used up to 1942.

Ju 88 intruder

Following the suspension of night intruder operations over the UK, 2./NJG 2 was sent to Catania in Sicily to bolster local night defences. This Ju 88C-2 with a white theatre band on the fuselage was flown by Leutnant Heinz Rökker. Rökker became a 64-victory ace, all kills scored with NJG 2.

Screech Owl

The Do 17Z-7 Kauz II (Screech Owl II) was armed with four MG 17s and two MG FF cannon in the nose and two MG 15s for self-defence. This aircraft was with 2./NJG 2 at Gilze-Rijen, the red spinner tips denoting an aircraft of the 2nd Staffel, of which Erich Jung, whose aircraft this is, was CO.

searchlights to intercept it; this is where the problems arose. Both bomber and night-fighter were now in front of the sound locators, whose operators – often inexperienced – became confused by the 'sound-salad' they were picking up. Würzburg-A and sound locator reports were frequently at odds. There was an equal chance of the night-fighter being identified as the bomber. The searchlight crews did not know for which aircraft they were supposed to be searching. And more than one night-fighter pilot, following the instructions of a bemused ground controller, ended up chasing himself!

It is little wonder that the new procedure found little favour. The commander of the searchlight regiment suggested that the Würzburg-A should be used to control a single 'master' searchlight (a system that was later adopted). The night-fighter pilots themselves were even more critical. Despite Kammhuber's strict instructions to adhere to the new method, at least one Gruppenkommandeur took matters into his own hands. Hauptmann Radusch instructed his I./NJG 1 crews to revert to Falck's original idea of waiting behind the searchlights and attacking the target within the illuminated zone. This they did on the night of 14/15 October, claiming five kills in the process, a figure subsequently reduced to three. Oberleutnant Ehle's neighbouring II./NJG 1 did not score a single success using the 'approved' method. (It is not known, incidentally, whether Radusch's departure to take command of the untried I./NJG 3 immediately after this event was a promotion 'sideways' as a sign of official displeasure, or a mark of recognition of his ability to get things done!)

Himmelbett for Kammhuber Line

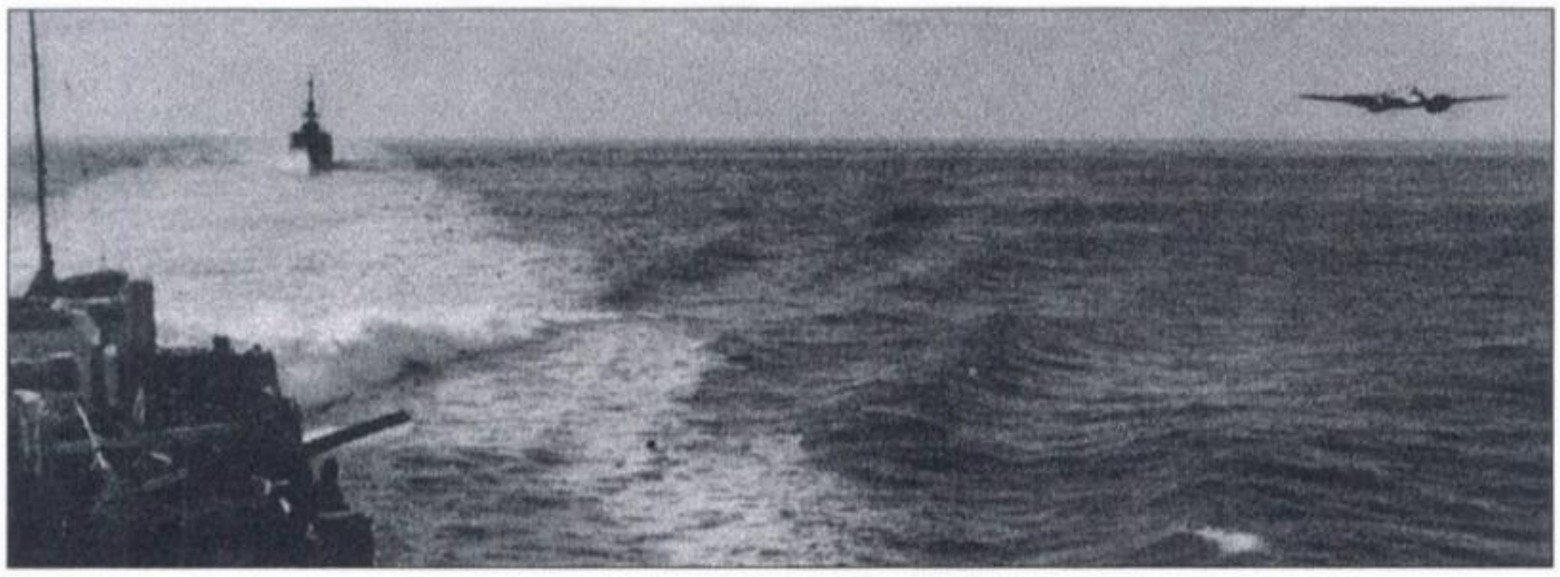
Gradually, however, with increasing numbers of Freyas at his disposal and the introduction of the new, larger Würzburg-Riese (Giant Würzburg) radars, Kammhuber evolved the definitive arrangement which would form the basis of his entire defensive strategy. The searchlight regiments were divided into their individual batteries, which were deployed at roughly 40-km (25-mile) intervals in a chain of connecting 'boxes'. Each box also contained three separate radars: a Freya for early warning and overall surveillance, and two Giant Würzburgs – one to track the target bomber, the second to monitor the intercepting fighter. This system of one-to-one control – code-named Himmelbett (four-poster bed) by the Luftwaffe – was the very core of the Kammhuber Line. More and more boxes would be added to the chain until, by mid-1942, it formed an unbroken defensive wall stretching in a dogleg from Denmark to France.

This ideal was still more than a year away. In its infancy, Himmelbett was an imprecise science. Few results were achieved on the darker nights, and aircrews looked forward to the better visibility of the full moon periods. Success was still being measured in terms of individual victories. At the close of 1940 night-fighters had claimed the destruction of 42 RAF aircraft; the flak batteries, 30.

By the beginning of 1941 Kammhuber's fighter strength, due to continuing inexperience and a spate of accidents, had sunk to a low ebb. On average, each of his Staffeln (nominally of 12 aircraft) could muster less than four fully operational crews. The situation was exacerbated by the RAF striking at a succession of widely dispersed targets. In the autumn, for example, I./NJG 1 had been stationed at Gardelegen to protect Berlin. Following raids on Hamburg the Gruppe was transferred to Stade. The mounting tenor of attacks on the Ruhr then necessitated detachments being sent to Dortmund, Düsseldorf and other airfields along the Rhine. In March I./NJG 1, commanded since Radusch's departure by Hauptmann Werner Streib, finally arrived at newly expanded Venlo, which was to be their permanent base until the Luftwaffe's withdrawal from the Netherlands in September 1944.

The two Bf 110-equipped Staffeln of II. Gruppe, 5. and 6./NJG 1, led an equally nomadic existence during the first half of 1941. After flying Henaja missions over the western (Belgian) extremities of the incomplete Kammhuber Line, they first moved north to Schleswig, and thence to Stade to help defend Hamburg. It would fall to III. Gruppe's Feldwebel Karl-Heinz Scherfling, though, to claim the very first of the many hundreds of RAF four-engined bombers to fall victim to night-fighters when he despatched a No. 7 Squadron Stirling, N6011, over Lingen shortly before midnight on 9 April.

Meanwhile, 4./NJG 1, which operated a mix of Bf 110s and a few Do 17s – later supplemented by the more powerful Do 215 – had been stationed at Leeuwarden. This base also housed a small team from the Rechlin research



An unlikely sojourn for the night-fighter force was flying escort for the 'Channel dash' of the capital ships* Scharnhorst, Prinz Eugen *and* Gneisenau. *The lower photo shows aircraft of II./NJG 1 over the* Scharnhorst. *These daylight patrols proved mostly uneventful for the night-fighter crews.

Left and below: The Do 217 served in limited numbers as a night-fighter but was really too unwieldy for the role. This aircraft is a pre-production Do 17J-2 with FuG 202 radar.

centre which was carrying out tests with the new Würzburg-Riese ground radar. Now Leeuwarden was about to host trials of an even more portentous nature.

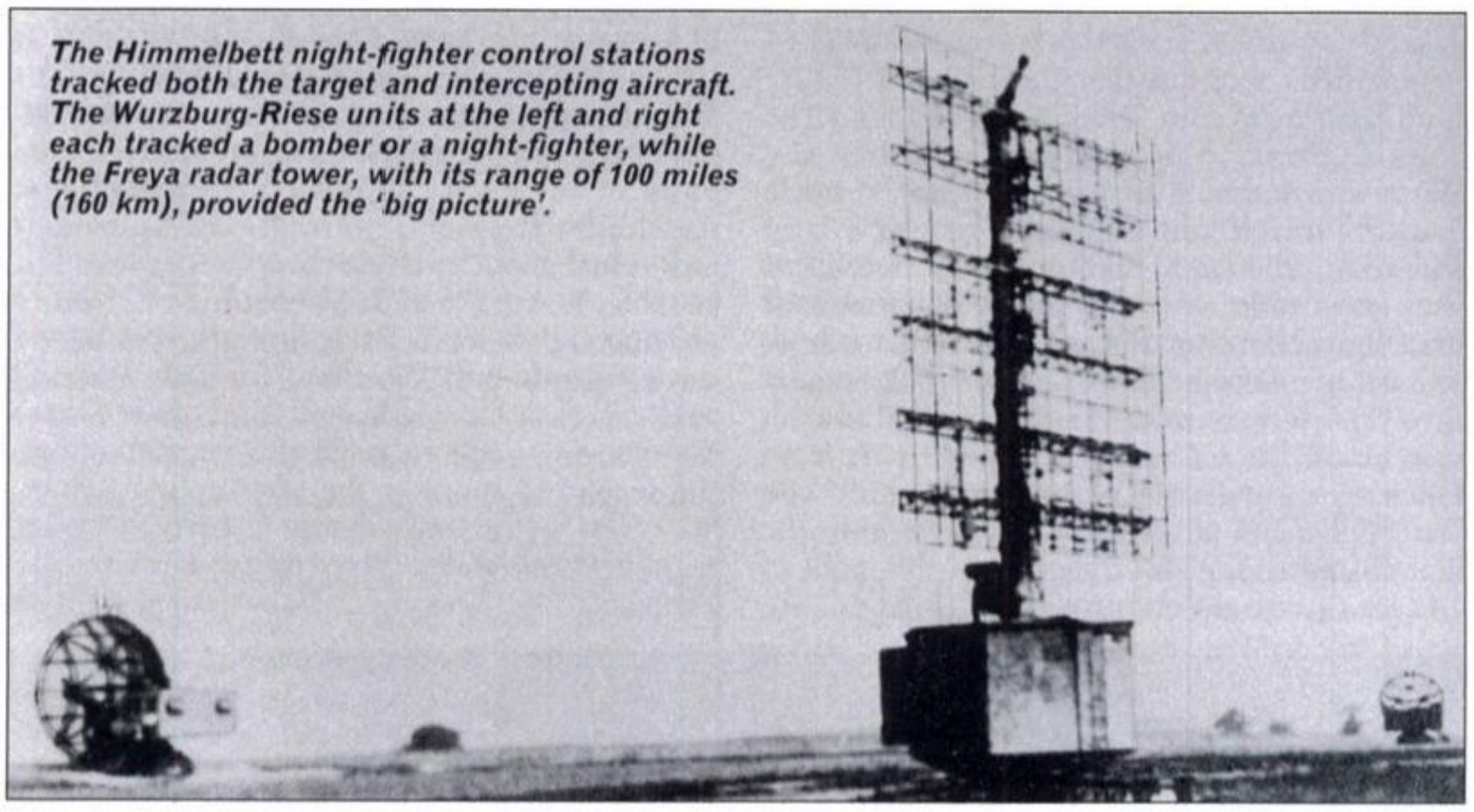
Urgent radar request

Late in 1940 Kammhuber had urgently requested an airborne radar for his fighter force. Once again, it was the firm of Telefunken which responded to his plea by suggesting that such a device might be adapted from the existing Lichtenstein-A radio altimeter. Although this proved to be possible, the operating wavelength necessitated an external aerial array. A trial installation was mounted in the Do 215B-5 of Oberleutnant Becker (the same Ludwig Becker who had achieved the first ground-controlled Dunaja kill the previous October). Becker was an equally willing convert to the new system. After some initial teething troubles, he was also able to gain the Nachtjagd's first airborne interception victory early on 9 August 1941 by bringing down Wellington T2625 of No. 301 (Polish) Squadron near the Dutch-German border. Over the ensuing weeks he was to claim the destruction of four more RAF bombers; the last – on 2 October – reportedly was picked up by his radar operator at a range of some 2800 m (9,185 ft).

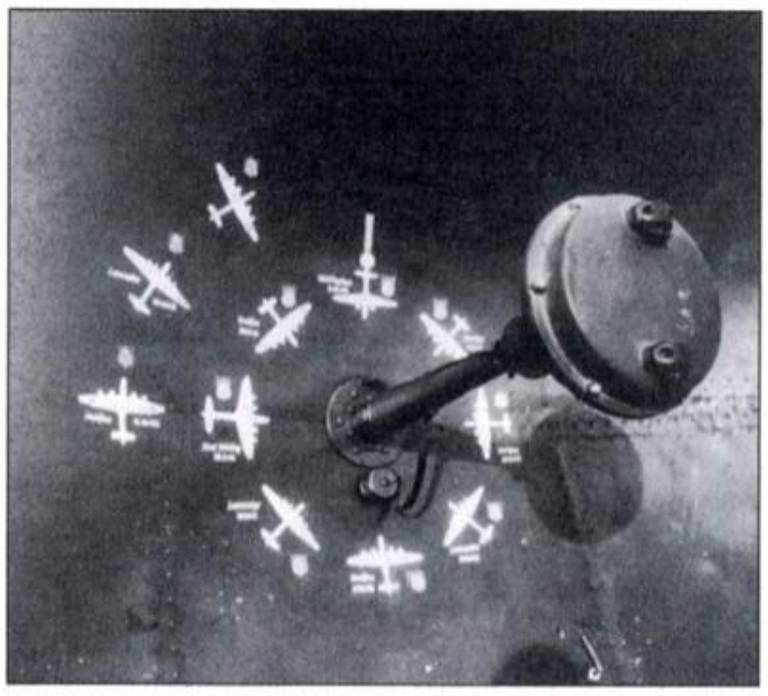
The Lichtenstein in Becker's machine was the only set in existence and doubts still surrounded its future development. The Luftwaffe's High Command initially vetoed the use of external aerials on the grounds that they would adversely affect an aircraft's performance. A change to short wavelength radar would have enabled the aerials to be fitted inside the nose of the aircraft (as had already been done by the British), but Hitler himself, in turn, was reluctant to impose a ban on any such new development work. The High Command perforce lifted its veto. It would be another year, however, before Lichtenstein began to enter service in any numbers. When it did, its distinctive nose-mounted aerial arrays – some more cumbersome than others, depending on the mark of radar installed – would remain an unmistakable characteristic of the Luftwaffe night-fighter until the end of the war.

In the late summer/early autumn of 1941 the award of six more Knight's Crosses attested to the growing success of the Nachtjagdwaffe. Falck and Streib had been decorated in October 1940, primarily for the part they had played in first establishing the night-fighter arm. Among the new recipients was General Kammhuber, now honoured for his untiring work in building up the force.

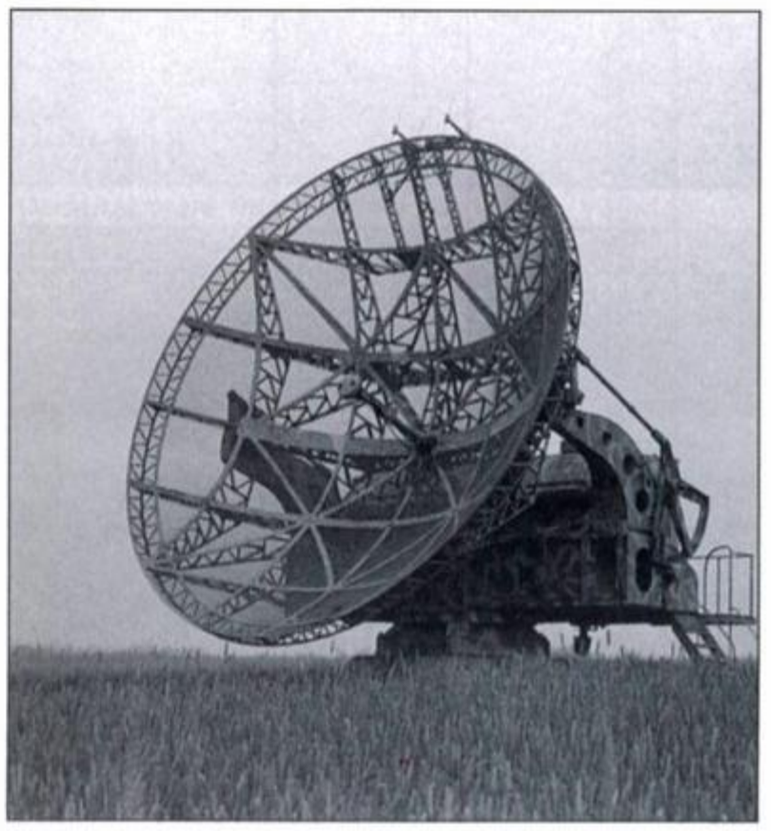
The other five were all operational pilots – two intruders of I./NJG 2, as described earlier – and three from NJG 1: Paul Gildner, Reinhold Eckardt and Helmut Lent. The latter would emerge as one of the outstanding personalities of the night air war over Germany, being one of only two pilots to achieve more than 100 nocturnal victories. He was already proving to be a natural combat leader. Oberleutnant Lent's 4. Staffel alone was responsible for 65 of the first 100 kills claimed by II./NJG 1 (the 100th –



The Himmelbett night-fighter control stations tracked both the target and intercepting aircraft. The Wurzburg-Riese units at the left and right each tracked a bomber or a night-fighter, while the Freya radar tower, with its range of 100 miles (160 km), provided the 'big picture'.

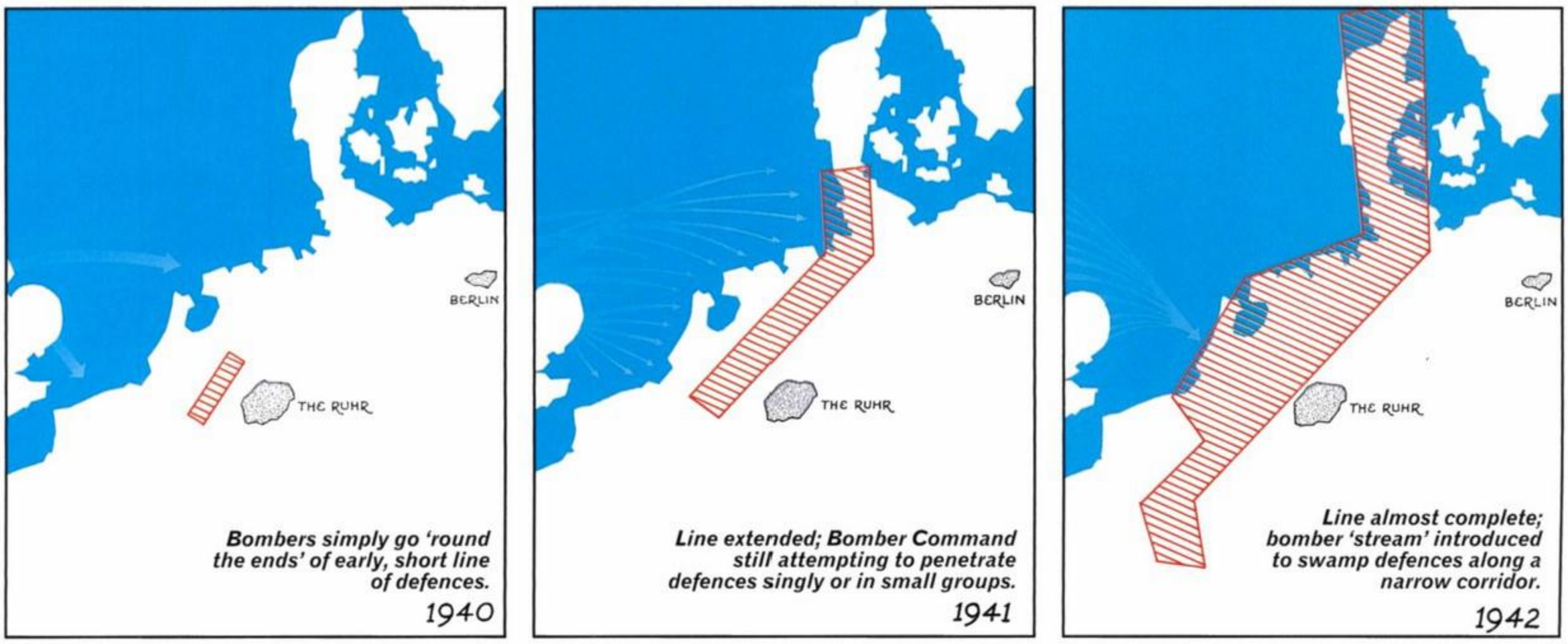


Below: A Würzburg-Riese (Giant Würzburg). These radars used a pencil beam to track a single target. Range was, at best, 50 miles (80 km). Each had a crew of six, and over 1,500 were built from 1942.



Left and above: Würzburg-A was the main radar used in conjunction with flak batteries. The unit above claimed a part in the destruction of a Wellington, six Halifaxes, three Lancasters and a Stirling. The operator's scope was in an exposed position at the rear. Wurzburg-A had a range of about 25 miles (40 km). In addition to flak laying, it was occasionally used for early warning.

Development of the Kammhuber Line


BERLIN
THE RUHR
Bombers simply go 'round the ends' of early, short line of defences.
1940
BERLIN
THE RUHR
Line extended; Bomber Command still attempting to penetrate defences singly or in small groups.
1941
BERLIN
THE RUHR
Line almost complete; bomber 'stream' introduced to swamp defences along a narrow corridor.
1942

a No. 75 Squadron Wellington brought down over Hamburg on the night of 15/16 September – was marked by a formal dinner attended by many of the city's leading dignitaries). An obvious candidate for promotion, Lent was given command of II./NJG 2 a few weeks later.

Increase in strength

Nachtjagdwaffe strength increased suddenly in November 1941, and on 1 August Kammhuber's Nachtjagddivision had been elevated to the status of a Fliegerkorps in readiness. Hitherto, NJGs 2 and 3 had existed in single Gruppe strength only, and both had been subordinated to Falck's NJG 1 for administrative purposes. Now each was to be brought up to full complement by the activation of its own Geschwaderstab and two additional Gruppen. On 1 November Stab NJG 2 was formed at Gilze-Rijen, and II./NJG 2 was created at Leeuwarden by the simple expedient of adding cadres provided by 4. and 6./NJG 1 to the already extant 4./NJG 2, which had been operating as the Kommando Wittmundhaven. III./NJG 2 would not be activated until March 1942.

In the case of NJG 3, use was again made of the almost moribund Zerstörer arm. Although the Geschwaderstab was created from scratch, II. and III./NJG 3 came into being by the straightforward redesignation of II./ZG 2 and II./ZG 76, respectively. This last unit was the famous 'shark-mouth' Gruppe, which continued to proudly sport its flamboyant nose markings for some time after its redeployment as night-fighters. While NJG 2 was slotted into the Netherlands sector of the Kammhuber Line, NJG 3's Gruppen took up station in northern Germany along an arc from Stade to Schleswig, their task being the nocturnal defence of the North Sea coastal belt.

At the beginning of 1942 there were further radar developments. On the early warning front, manufacturers were invited to submit proposals for an improved Freya. Using the same formula which had worked so well with Würzburg, namely enlarging the size of the reflector to increase the range, two designs evolved, both of which combined a number of Freya reflectors to form one giant array.

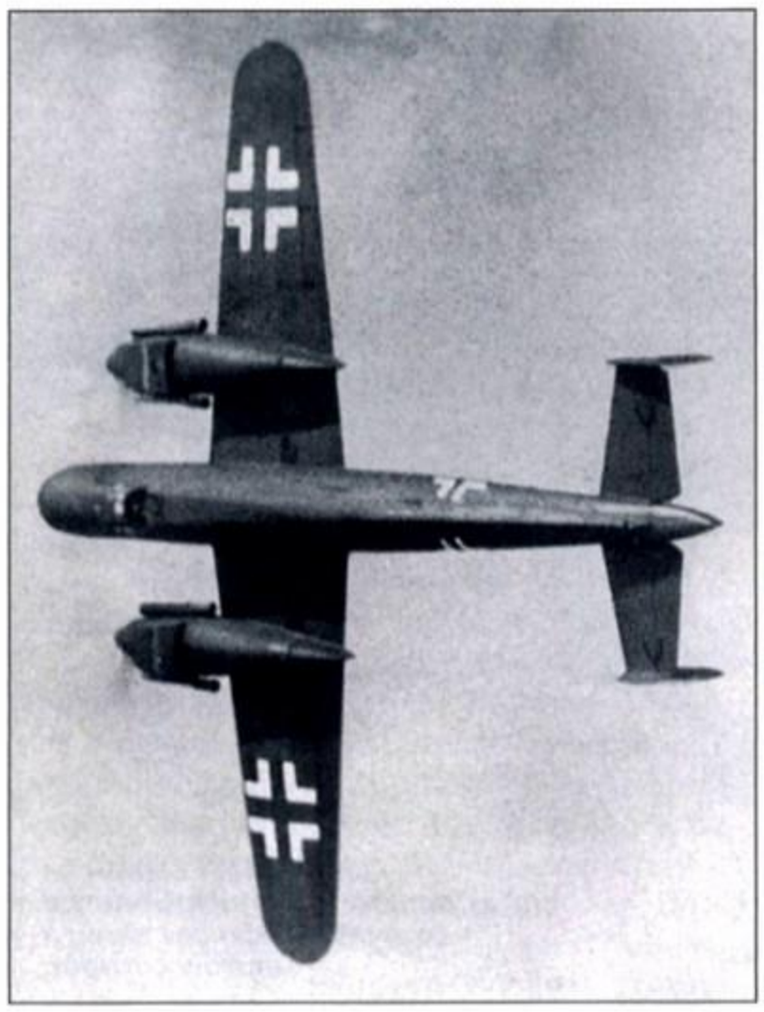
Mammut radar

The Mammut (Mammoth) comprised 16 Freya reflectors made into a giant 'bedstead' 30 m (98 ft) across and 10 m (33 m) high (roughly the size of a tennis court). This proved capable of detecting high-flying aircraft at a range of 300 km (185 miles) but, like the smaller Freya, was still incapable of measuring altitude. Another major drawback was that the Mammut's three-masted support structure did not rotate. In order to track enemy aircraft on both their approach to, and exit from, German airspace, Mammut reflectors were therefore often erected in pairs, back-to-back. By contrast, the Wassermann (literally, Waterman), which consisted of eight or more Freya reflectors arranged vertically on a rotating steel tower 60 m (197 ft) high, provided accurate details of the range, bearing and height of an aircraft over a similar 300-km distance. Rightly described as 'the finest early warning radar to be produced by either side during World War II', the Wassermann appeared in a number of versions, the later models having an overwater range of 380 km (236 miles).

At this time, too, the first four night-fighters equipped with production Lichtenstein airborne radar were delivered to Leeuwarden. The crews, with the exception of the ever-enthusiastic Becker, were initially most reluctant to have anything to do with them. Many of the veteran, 'seat-of-the-pants', ex-Zerstörer pilots, accustomed to being in complete control, found it difficult to adjust to the disembodied voice of their radar operator jockeying them into a position to attack. By the same token, a number of the older wireless operators, despite retraining, felt overburdened by the new responsibility thrust upon them. The scepticism at first displayed by some COs (including Helmut Lent, later a complete convert) percolated down through their units. It was not unusual for newly received radar-equipped machines to be standing idle, while those without the 'drag-inducing aerials and box-of-tricks in the back seat' were up aloft hunting RAF bombers.

With Telefunken soon turning out

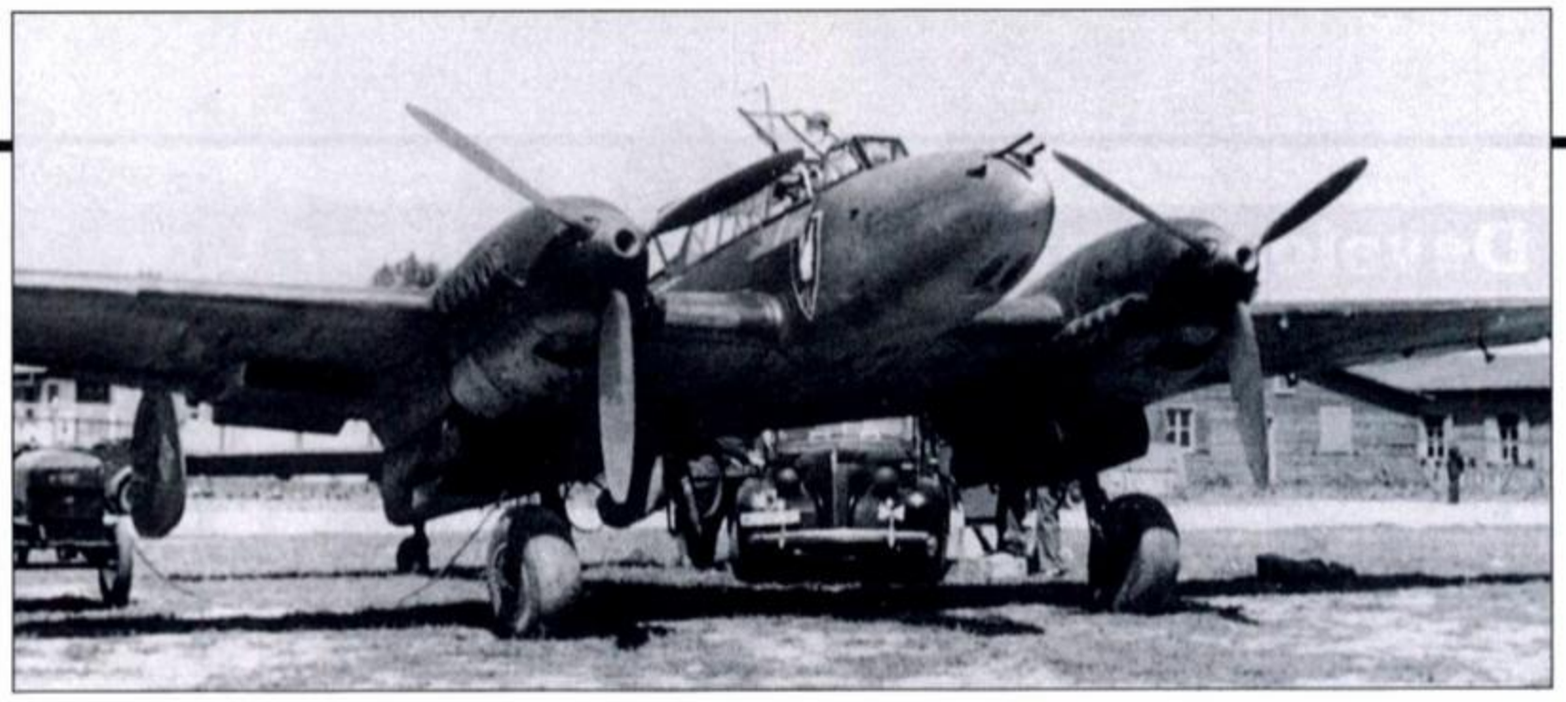
One of the most successful night-fighting teams was that of Helmut Lent (left) and his radio-operator/gunner Oberfeldwebel Walter Kubisch (right). Lent is seen here wearing the Knight's Cross with Oak Leaves and Swords (the latter awarded later in the war). Kubisch was the second 'backseater' to receive the Knight's Cross. He claimed one Lancaster himself with their Bf 110's rear guns.



A Do 217N banks away from the camera. The oversized underwing national insignia compromised the camouflage but offered some protection from 'friendly' AA gunners.

Lichtenstein sets at a rate of 60 per month, the Führer decided that Kammhuber no longer had need of his searchlights. He ordered them to be relocated closer to the cities and industrial centres being targeted by the RAF. This gradual dismantling of the 'illuminated zones' along the Kammhuber Line effectively compelled the night-fighter crews to embrace the new technology, which, they soon came to realise, was much more effective than *helle Nachtjagd* had ever been.

Then, in mid-February 1942, the one-time Zerstörer pilots of II./NJG 1 enjoyed a brief reminder of earlier days. Hauptmann Ehle's Gruppe had transferred to St Trond, in Belgium, on 15 January 1942 to fly *helle Nachtjagd* missions while awaiting re-equipment with Lichtenstein (which would not be completed until August). Their routine was suddenly interrupted when they were ordered to provide dawn and dusk cover for the three capital



Above: Falck led NJG 1 from June 1940 until June 1943 – this Bf 110C is said to be one of his later personal aircraft. Note that it continues to display the NJ badge.

ships of the Kriegsmarine – the *Scharnhorst*, *Gneisenau* and *Prinz Eugen*, all in the French port of Brest – which were preparing to make their now-historic 'Channel Dash' to home waters.

Protecting the navy

Tasked with protecting the flotilla at first and last light on each day of the dangerous passage from the Atlantic, through the English Channel, to the North Sea, II./NJG 1's 30 Bf 110s were deployed on coastal fields along the projected route. Escorted by seven destroyers, the trio of heavy ships slipped out of Brest just before midnight on 11 February, and was picked up by the first of the Gruppe's Bf 110s off Cherbourg at 08.30 the following morning. II./NJG 1's naval escort duties were to occupy them for a full fortnight. After shepherding the two battle-cruisers into north German ports, they found themselves flying over familiar territory when they then accompanied the *Prinz Eugen* northwards to Trondheim in Norway. The whole operation apparently passed without incident for the night-fighters. The Gruppe claimed no enemy aircraft destroyed, and the only reported casualties were 6. Staffel's Leutnant Birkenstock and his crew, who were injured when their Bf 110 suffered engine failure shortly after taking off from Bremen on a transfer flight to Lüneburg.

Early in March 1942 Major Karl Hülshoff's NJG 2 was finally brought up to full strength when the Geschwader's own Ergänzungsstaffel (crew training and replacement squadron) was redesignated to form the Stab of a III. Gruppe. All three component Staffeln of this new III./NJG 2 would be created from fresh intakes of personnel arriving over the course of the next few weeks.

It was at this juncture, too, that NJG 4 properly came into being, having undergone a somewhat lengthy and complicated period of gestation. Orders had first been given for its formation at Metz, in France, as long ago as January 1941. Since that date a Geschwaderstab, I. and II. Gruppen (previously Stab, I. and II. Gruppen, respectively, of ZG 26) had all existed for varying short lengths of time. Then Stab NJG 4 had exchanged places with that of NJG 3, while I. and II./NJG 4 subsequently reverted to their former identities as I. and II./ZG 26.

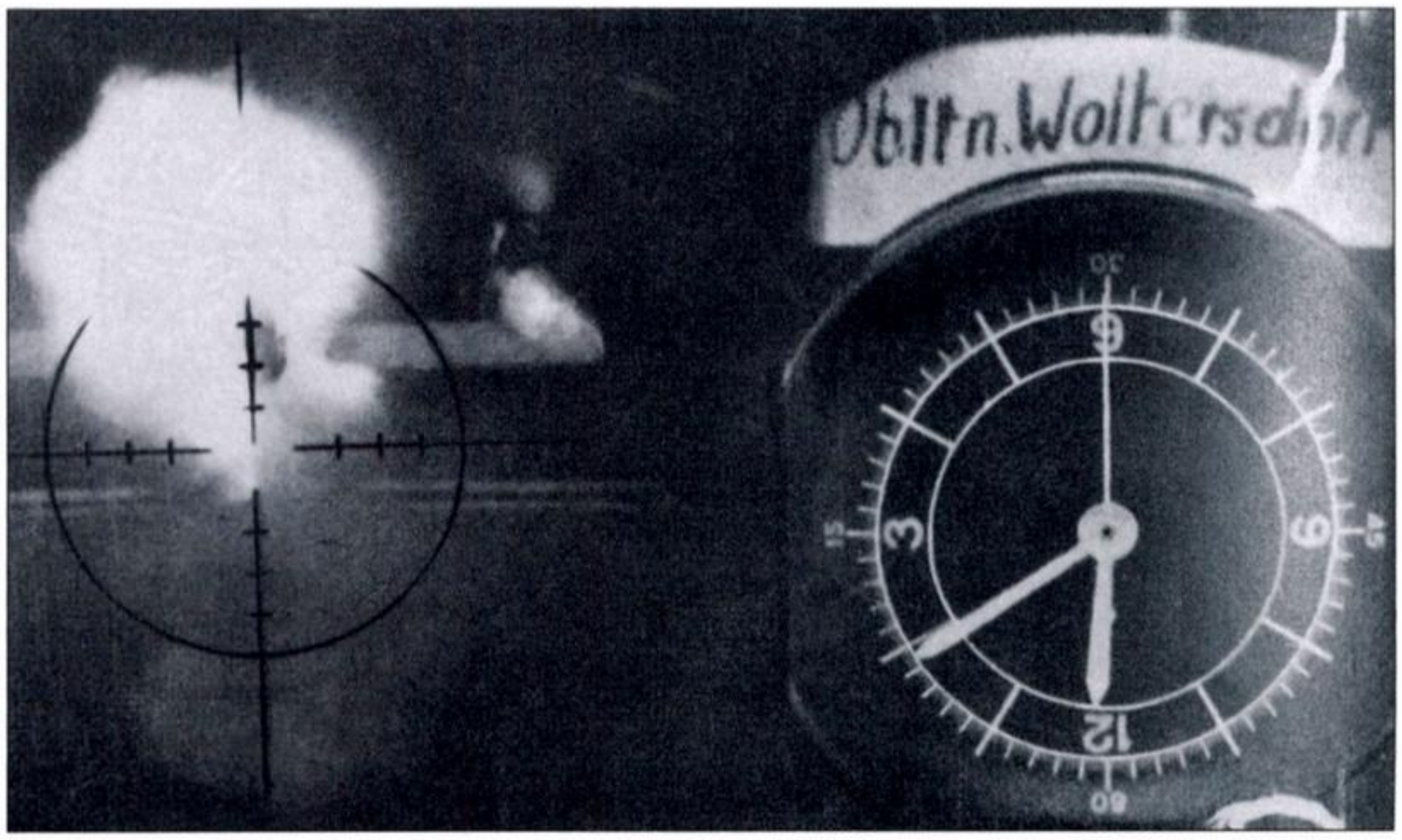
On 1 May 1942 (with the Stäbe of NJGs 3 and 4 having changed places again in November 1941!), a fresh start was made. A new II./NJG 4 was formed, making use once more of ZG 26 to provide a small cadre, but composed in the main of aircrews straight from training schools. III./NJG 4, by contrast, consisted of three existing Staffeln drawn directly from the ranks of NJG 1 (one from each Gruppe, which had then, in turn, to make good their own losses by setting up three new Staffeln). A second I./NJG 4 would not be activated until October.

While this convoluted process was going on, Kammhuber's opposite number had been preparing an unwelcome surprise. Air Marshal A. T. 'Bomber' Harris, newly appointed Commander-in-Chief of RAF Bomber Command, had inherited an expanding, but still relatively blind, bomber force. Hitherto, indi-

Nachtjagd's first 20 operational losses

DATE	TYPE/(IDENTITY)	CREW	UNIT	CAUSE	LOCATION
28/29.6.40	Bf 110C-4 (G9+GK)	Uffz. Schwarz (w), Fw.Palm (w), Fw. Born (d/w)	1./NJG 1	Crashed	München-Gladbach
25/26.7.40	Bf 110C-4	Lt Pack (+), Uffz. Hildebrandt (+)	3./NJG 1	v.Wellington	Coesfeld
27/28.7.40	Do 17Z-10	Fw. Buck (+), Fw. Schmidt (+)	5./NJG 1*	Crashed	Grefrath
28/29.7.40	Bf 110C-4	Fw. Hahn (+), Uffz. Huber (+)	3./NJG 1	Crashed	Ennigerloh
17/18.8.40	Ju 88C-2 (4D+GZ)	Ofw. Zenkel (H), Fw.Schramm (B), Gefr. Roth (H)	4./NJG 1*	Blenheim N/F	off Spurn Head
29/30.8.40	Ju 88C-2	Lt Bregant (+), Gefr. Schmidt (+), Gefr. Lönnecke (+)	6./NJG 1*	Crashed	Elsdorf
1.9.40	Bf 110C-6 (G9+BL)	3Lt Schmitz (w), Gefr. Vonjahr (u).	3./NJG 1	Enemy action	Lippborg
14/15.9.40	Bf 110C-7 (G9+FK)	Lt Xangelsdorf (+), Uffz. Winter (+)	2./NJG 1	Enemy action	Gardelegen
16/17.9.40	Ju 88C-2 (R4+AH)	Fw. Palm (+), Gefr. Reinfsch (B), Gefr. Haberland (B)	3./NJG 2*	AA (UK)	North Sea
13/14.10.40	Do 17Z-10 (R4+DK)	Uffz. Gdtz (w), Uffz. Herden (w), Uffz. Dreher (w)	2./NJG 2*	Crashed (L)	Gilze-Rijen
16/17.10.40	Bf 110D-1 (3H+AH)	Oblt Zimmermann (+), Gefr. Hakowski (+)	4./NJG 2*	Crashed	Capelle
19/20.10.40	Ju 88C-2	Fw. Schlicht (w), Uffz. Harschall (u), Gefr. Nitz (u)	3./NJG 2*	Crashed (L)	Eindhoven
21.10.40	Bf 110D-0	Oblt Walter (+), Uffz. Hoffmann (+)	8./NJG 1	Crashed (T/O)	Stendal
28/29.10.40	Bf 110D-2	Uffz. Bertram (+), Ofw. Lorenz (+)	9./NJG 1	Enemy action	Tellingstedt
1/2.11.40	Ju 88C-2 (R4+0L)	Uffz. Lang (+), Gefr. Linke (+), Gefr. Gerardi (+)	3./NJG 2*	Enemy action	Unknown
8/9.11.40	Do 172-10 (R4+HK)	Ofw. Schmidt (u), Ofw. Rosenberger (u), Uffz. Lang (w)	2./NJG 2*	N/F (UK)	Gilze-Rijen
23/24.11.40	Ju 88C-4 (R4+BB)	Maj. Heyse (H), Uffz. Bauda (M), Uffz. Fiedler (M)	Stabl./NJG 2*	Enemy action(?)	North Sea
23/24.11.40	Ju 88C-4 (R4+BK)	Ofw. Schlicht (M), Uffz. Harschall (H), Gefr. Nitz (M)	3./NJG 2*	Enemy action(?)	North Sea
20/21.12.40	Ju 88C-2 (R4+TH)	Gefr. Ludescher (+), Gefr. Rohde (+), Gefr. Dempewolf (+)	1./NJG 2*	Crashed	Gilze-Rijen
20/21.12.40	Ju 88C-2 (R4+KL)	Oblt Heyer (+), Fw. Schottke (+), Ogfr. Schneider (+)	3./NJG 2*	AA (UK)	South Cockerington

*Intruder unit L= on landing T/O= on take-off += killed w= wounded d/w= died of wounds M= missing u= uninjured



A rare night gun camera image taken by Oberleutnant Helmut Woltersdorf of 7./NJG 1 shows the destruction of an unidentified British twin-engined bomber. The date is unknown, but predates the second '1,000-Bomber' raid on Cologne (1/2 June 1942) during which Woltersdorf was killed attempting an emergency landing in a combat-damaged Bf 110F-4 'G9+CR'.

vidual bomber crews had been free to select their own routes to and from their assigned targets, with each navigator working out his preferred course to avoid known concentrations of flak. The inevitable result was that nearly every raid consisted of a haphazard collection of bombers, often widely separated by time and distance, having to brave the Kammhuber Line singly or in small groups; this is exactly what the Himmelbett system had been designed for. In the early months of 1942, coincident with the activation of more Nachtjagdgruppen and the introduction of Lichtenstein, Bomber Command's average loss rates had risen by nearly 50 per cent.

British scientists, though, had recently developed a new radio navigation device. 'Gee' relied on ground transmitters radiating a series of pulse signals which effectively formed an invisible radio grid stretching over 600 km (373 miles) across the face of northern Europe. These pulse signals were displayed on a cathode ray tube in the bomber; by measuring the time intervals between two signals, the navigator was able to calculate and plot his position with a reasonable degree of accuracy (within 0.5 mile/0.8 km close to the transmitters, and within 6 miles/9.6 km at extreme range).

Breaking through the Line

Utilising his growing strength, and taking advantage of the possibilities offered by 'Gee', Harris planned to swamp a small section of the Kammhuber Line by sending his bombers across it in one concentrated mass. The two Würzburg-Riesen in each 40-km (25-mile) wide Himmelbett box could vector a night-fighter on to only one bomber at a time. An interception would normally take an average of 10 minutes, during which all other bombers crossing the box would be safe from aerial attack. It would be hard on those bombers intercepted, but Harris was prepared to sacrifice the few to guarantee the passage of the many. By combing his operational training units, Harris intended, for the first time, to put more than 1,000 bombers into the air; the target, dictated by the weather, was to be Cologne. On the night of 30 May 1942 the first 1,000-bomber raid in history was launched.

Harris's tactics appear to have paid off. Eighteen bombers are believed to have fallen victim to night-fighters over the Kammhuber Line, eight claimed by Walter Ehle's St Trond-based II./NJG 1, through whose sector the main attacking force flew. It is estimated that close to 900 aircraft reached and bombed Cologne. A total of 41 bombers in all failed to return, the highest loss suffered until then by the RAF in any one night.

The war in Europe had run nearly half its course. The two protagonists in the fight for mastery of Germany's night skies had grown in strength and expertise. The battle lines had been drawn. The attack on Cologne was just one raid in many. There would be others – more devastating, more costly – in the months ahead. It has been suggested that Harris's new-found ability to despatch 1,000 bombers against the Reich marked the 'end of the beginning' of the five-year struggle between Bomber Command and the Nachtjagdwaffe. The RAF obviously thought differently. The closing lines of a propaganda leaflet dropped by the thousands over Germany in the week following the raid on Cologne read: "The offensive of the Royal Air Force in its new form has begun." As far as Bomber Command was concerned, Cologne was the beginning of the end.

John Weal

Flak criss-crosses over Cologne during a raid on the city, silhouetting the famous Gothic cathedral and the equally-distinctive twin towers of St Gereon's church at the right.

Right: "The heaviest attacks by the Luftwaffe far outweighed by the RAF. More than 1,000 bombers sent on one raid," read a propaganda leaflet dropped following the Cologne raid.

DIE SCHWERSTEN ANGRIFFE DER LUFTWAFFE
VON DER R.A.F. WEIT ÜBERBOTEN

Mehr als 1000 Bomber auf einmal eingesetzt

IN der Nacht vom 30. Mai griff die Royal Air Force Köln mit weit über 1000 Flugzeugen an. Der Angriff wurde auf anderthalb Stunden zusammengedrängt. Der deutsche Sicherheits- und Abwehrdienst war der Wucht des Angriffs nicht gewachsen.

Premierminister Churchill sagte in seiner Botschaft an den Oberbefehlshaber des britischen Bomberkommandos am 31. Mai:

„Dieser Beweis der wachsenden Stärke der britischen Luftmacht ist auch das Sturmzeichen für die Dinge, die von nun an eine deutsche Stadt nach der andern zu erwarten hat."

Zwei Nächte darauf griff die Royal Air Force das Ruhrgebiet mit über 1000 Maschinen an.

Die Offensive der Royal Air Force in ihrer neuen Form hat begonnen

Gloster Meteor Variants

The Gloster Meteor has seldom been recognised for the extraordinary success that it was. It has been overshadowed in the popular imagination by Germany's sleek, swept-wing Me 262, which served in larger numbers during World War II and scored more kills. Never considered to be at the very 'cutting edge' in terms of outright performance, the Meteor enjoyed its moment of glory immediately after the war, setting the world air speed record. It served for decades after the war, proving to be a versatile, effective and popular aircraft. Meteors shot down superior MiG-15s in Korea, and gained air-to-air victories in Israeli hands, too, though their straight wings made them more effective at low level than at altitude, where aircraft like the F-86 and MiG-15 were soon king.

The fact that Gloster built Britain's first jet fighter has been ascribed to luck, since the original contract to build the E.28/39 jet-engined test aircraft was placed largely because Gloster's chief designer, George Carter, and Frank Whittle, the engine's inventor, knew each other, and were aware of the other's work. The E.28/39 was designed with considerable input from Frank Whittle, and the original contract specified that a payment of £500 would have to be made by Gloster to Power Jets to reflect this. Although designed as a test aircraft, the specification called for the designers to make provision for the possible later installation of armament, and for the aircraft to be based on then-current requirements for a fixed-gun interceptor. Two E.28/39s were built and were appropriately named Pioneer, though the name was little-used. Even before the first E.28/39 made its maiden flight on 15 May 1941, Gloster began looking at possible designs for a fully-operational jet fighter.

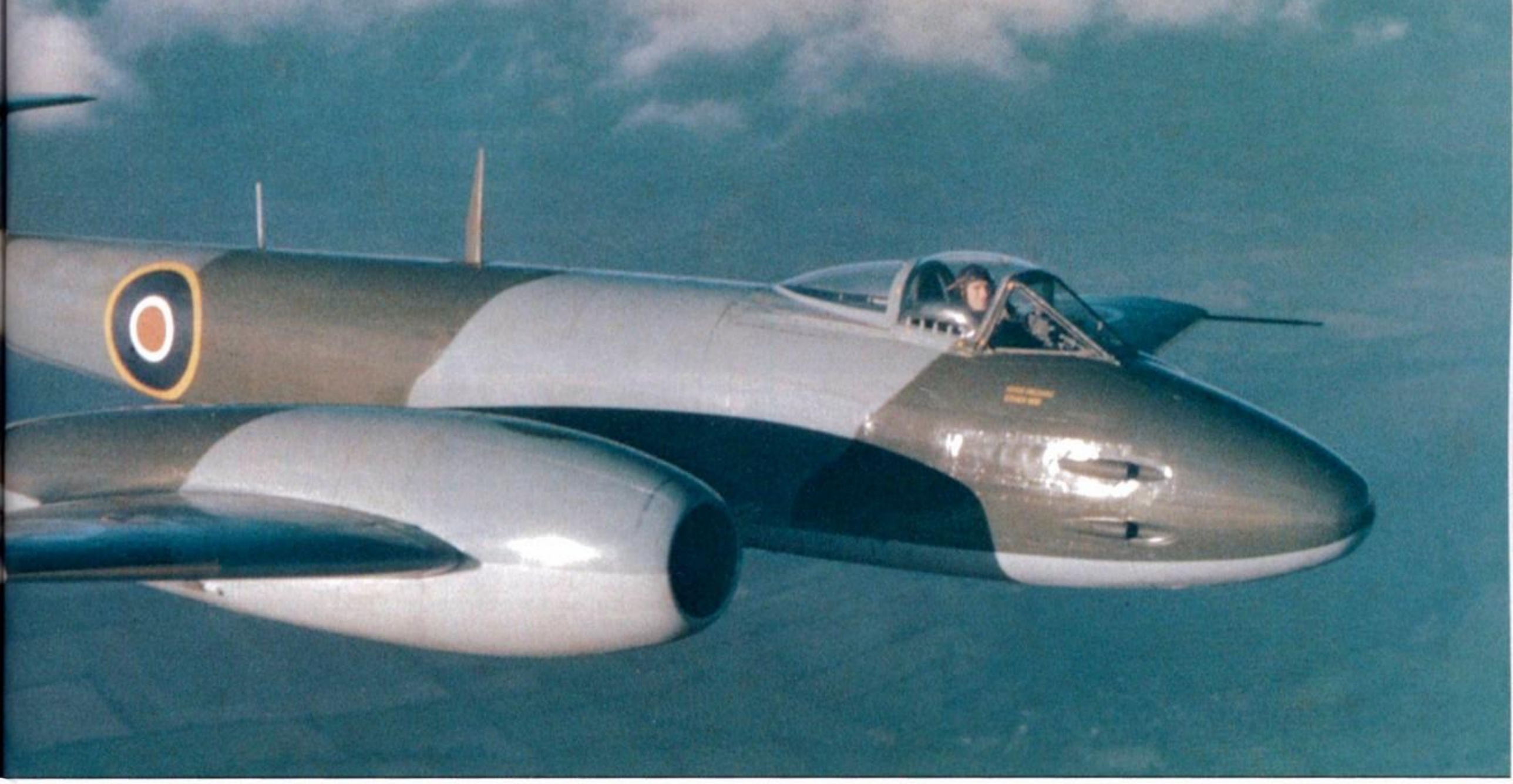
In view of the limited thrust produced by the early jet engines, it was apparent that a new jet fighter should be twin-engined, and specification F.9/40 was written around Gloster's early proposals, calling for an initial batch of 12 aircraft. This represented the birth of what was to become the Meteor. The Gloster F.9/40 was of conventional low-winged monoplane configuration, with mid-mounted engine nacelles at about one-third span, a tricycle undercarriage, and a mid-set tailplane. This layout allowed the main spars to run across the entire centre-section without breaks, saving weight and improving strength, while also allowing unbroken flaps and effective airbrakes close in to the fuselage. The fat engine nacelles were originally designed to accommodate the early centrifugal-flow turbojets; as jet engine design was refined, producing lighter engines with lower cross-sections or producing more power for the same cross-section, the nacelles allowed a variety of engines to be fitted with relatively little structural modification. The wing-mounted engines also left the fuselage clear, allowing it to be of minimum cross-section, and to have the armament of four 20-mm cannon (rather than the originally specified six) clustered together in the nose. Great emphasis was placed on providing a

Below: RAF Manston in January 1945 was the home of a No. 616 Sqn in the throes of replacing its Meteor Mk Is with Mk IIIs, this photograph showing examples of both marks. By the end of the month the squadron had moved from the Kent station to Colerne, and had sent a detachment to B.58/Melsbroek, Belgium. In March the entire squadron moved to Germany, where it was joined in April by a second F.Mk III unit, No. 504 'City of Nottingham' Sqn.

Variant Briefing

Gloster Meteor

Part One: Wartime development – F.9/40 to F.Mk 4



pressurised cabin, designed to maintain a pressure equivalent to flying at 25,000 ft (7620 m), even at the aircraft's planned 46,000-ft (14,020-m) ceiling. These were all factors which contributed to the Meteor's subsequent success and longevity. In the event, eight F.9/40 prototypes were built and flown, with a variety of engines, and their success cleared the way to full production.

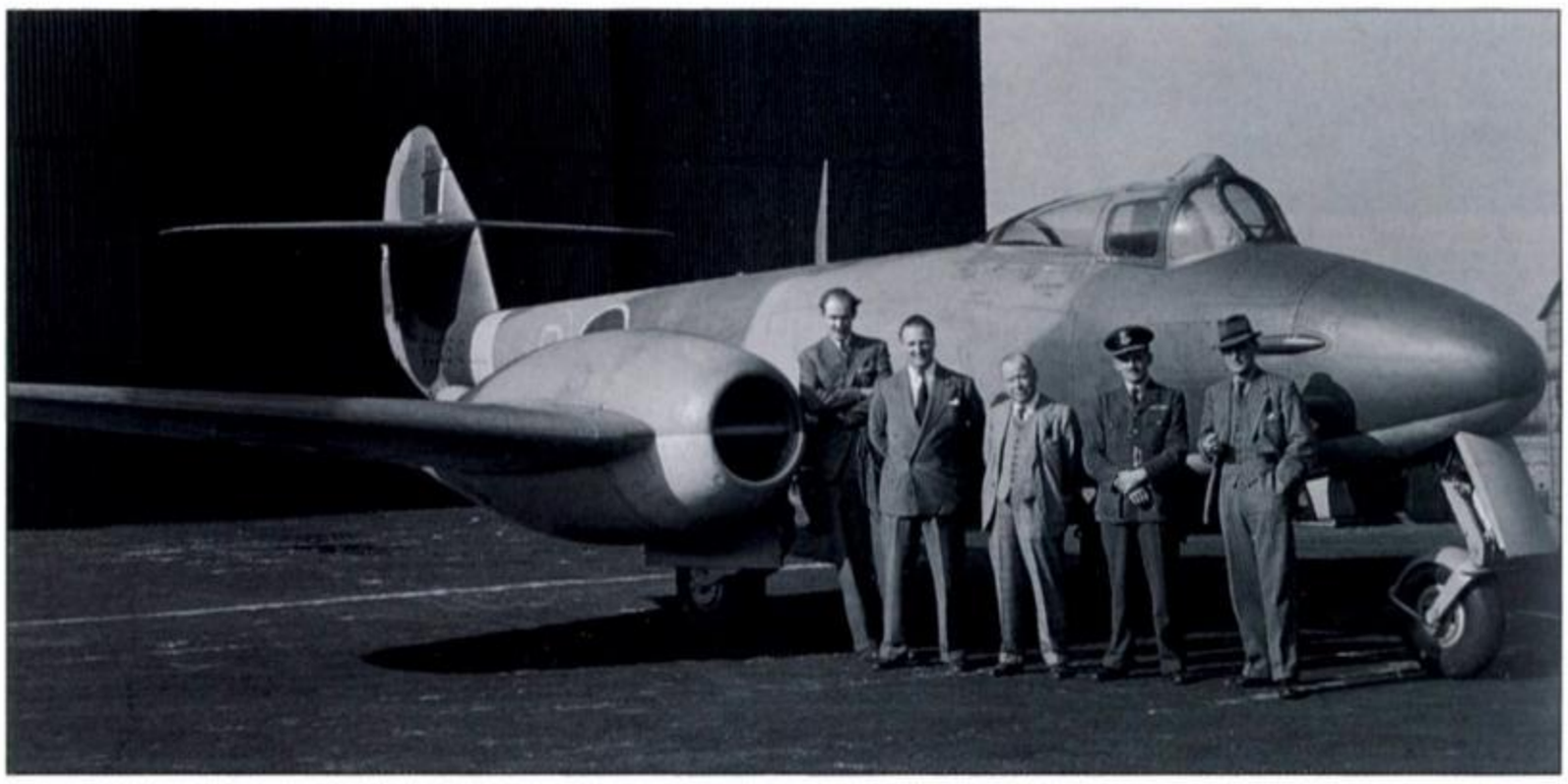
Slow pace of development

The slow pace at which development proceeded has been criticised, and contrasted with the Me 262; however, although the German aircraft flew first, it entered true front-line service only after the Meteor. Once the Me 262 was in service, though, production continued apace, and more examples were rushed into service. The Luftwaffe had its back against the wall, and was desperate for any tool with which it might stem the onslaught, even if the new fighters imposed a heavy toll on its own pilots – had it been a British or American aircraft, it would never have been judged ready for service. Britain had the luxury of being able to evaluate, consider and refine the Meteor, so that, by the end of the war, the two aircraft were leagues apart in terms of effectiveness and practicality.

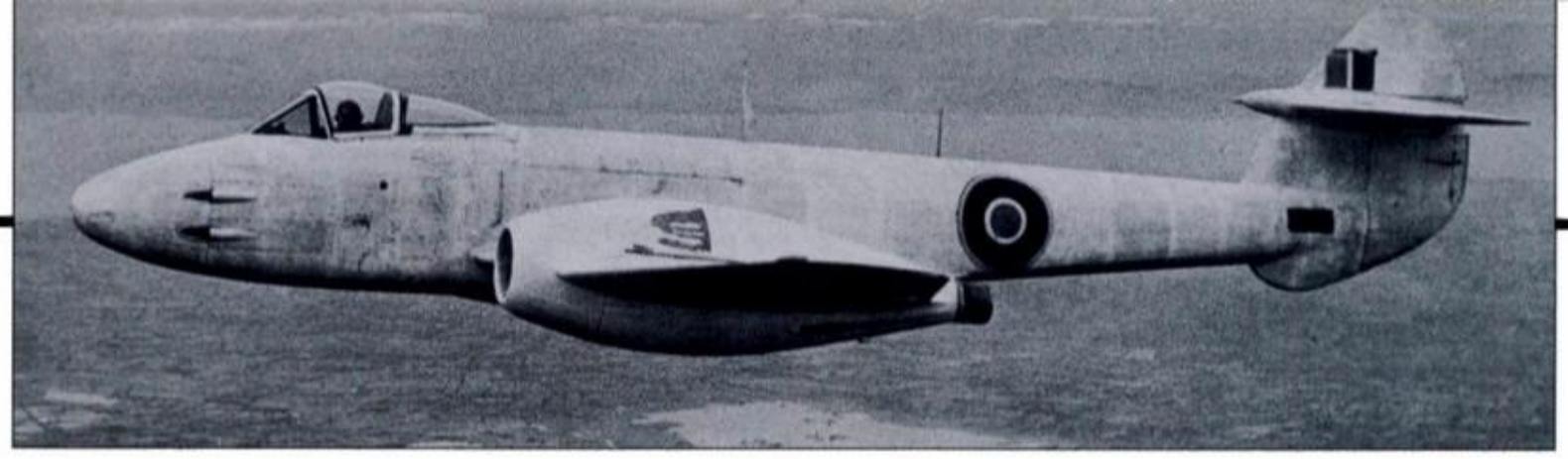
Although it undoubtedly pointed the way to the future, the Me 262 as built was far and away the inferior aircraft, with hopelessly unreliable engines, appalling asymmetric handling, overly complex operating procedures, poor altitude performance and less agility than the Meteor. The Me 262 may have been slightly faster than the Meteor (when it was airworthy at all, and not undergoing a 10-hour engine inspection or a 15-hour engine replacement), and the large number delivered to the front line may have

Above: The Mk 4, with long-chord engine nacelles housing Derwent V engines, began to reach RAF units in May 1945, as the war in Europe ended.

Below: The fourth F.9/40, DG206/G, provides the background for this July 1943 portrait of the key personalities in the Meteor's development, from left: John Crosby-Warren (test pilot), Michael Daunt (Gloster's then chief test pilot), Frank McKenna (Gloster's production manager), Wg Cmdr Frank Whittle (jet engine designer) and W. George Carter (Gloster's chief designer).



Gloster Meteor Variants



Below: By April 1945, No. 616 Sqn was based in Germany, its F.Mk IIIs finished in standard day-fighter camouflage. Here, EE274 kicks up a cloud of dust as ground crew start the aircraft on the PSP at B.158/Lübeck.

Above: The second Meteor variant to see wartime service was the F.Mk III, examples of which reached No. 616 Sqn in January 1945. In the hope that Me 262s could be drawn into combat, a flight of F.Mk IIIs was sent to Belgium. As a recognition aid, they were painted white overall. Initially barred from operating over enemy territory, the Meteors were making offensive sweeps over Germany by the end of the war, but no Luftwaffe jet fighters were ever encountered.

amassed a tally of some 150 Allied aircraft (far from the 780 claimed), but more than 100 were lost in air-to-air combat with Allied piston-engined fighters. By contrast, not one of the Meteors which served with the RAF's single Meteor squadron was lost to enemy action. The Me 262 was conceptually advanced, with its clean lines, swept-back wings and advanced air-to-air rocket armament, but the German fighter was not properly developed, and it reached the front line immature in a number of key areas. The Meteor, on the other hand, was deliberately modest, but was far more fully-developed and mature when it saw active service.

The Meteor entered service in July 1944 with No. 616 Squadron, then a Culmhead-based Spitfire unit. This was some time before the Me 262 entered front-line service as a fighter with Kommando Nowotny (3 October) and even pre-dated the first combat use of the Me 163 rocket fighter on 16 August, making No. 616 Squadron the world's first operational jet fighter squadron. The CO, Squadron Leader Andrew McDowell, five of his pilots, and Wing Commander H. J. Wilson converted to the Meteor at Farnborough, then formed a 'high speed' flight at the squadron's forward operating base at Manston. Despite its twin engines and tricycle undercarriage, the Meteor was an easy aircraft to fly, and conversion was simple and straightforward, even with no two-seat trainer version. This was in direct contrast to the Me 262, which proved so dangerous to its pilots that a two-seat training version had to be developed as a matter of urgency, and conversion to which entailed going through a formal training syllabus with a dedicated training unit.

No. 616 Squadron's Meteors began flying 'Anti-Diver' patrols on 27 July, and on 4 August Flying Officer 'Dixie' Dean (in EE216) scored the Meteor's first kill, nudging a V-1 over with his wingtip after his cannons jammed; minutes later, Flying Officer Roger downed another with cannon fire. The squadron eventually accounted for 13 V-1s, before the launch sites were overrun.

Left: On 20 September 1945 a modified Meteor Mk I powered by the first world's first turboprop powerplant took to the air. Power came from two Rolls-Royce RB.50 Trents – effectively Derwent II turbojets fitted with a suitable gearbox to drive a Rotol five-bladed propeller of 7 ft 11 in (8.22 m) diameter. As the first aircraft of its type, it was flown by a number of notable test pilots before reverting to standard Mk I configuration in late 1948.

Jet fighter familiarisation

The Meteor F.Mk Is were used to familiarise USAAF bomber crews with jet fighter tactics and performance before No. 616 moved to RAF Colerne to re-equip with the improved Meteor F.Mk III in December 1944. On 20 January 1945, four aircraft were detached to Melsbroek in Belgium, moving to Gilze-Rijen where the rest of the squadron joined the detachment. Thereafter, the Meteors flew in the air defence role, seeing little action until April due to an order prohibiting them from flying over enemy-held territory. The biggest danger to the Meteor pilots came from Allied anti-aircraft guns, so the aircraft were painted white overall as a recognition aid. The Meteors soon proved tough and rugged enough to operate from primitive strips, and began amassing a tally of strafing kills of enemy aircraft. The first opportunity to score an air-to-air victory came when four Meteors engaged a gaggle of Fw 190s, but were forced to break off when attacked by friendly Tempests and Spitfires. On 2 May 1945 a single Meteor forced a Fieseler Storch to land, then destroyed it on the ground. These Meteor F.Mk IIIs proved as reliable and easy to operate as the tried-and-tested Spitfires and Tempests, even when operating from primitive forward airstrips, some with grass runways, some with PSP, and all without specialised support. No. 616 Squadron suffered only two Meteor losses, in a mid-air collision.

Meteor production continued at a fast pace after the war ended, allowing the first three-squadron wing to form at Bentwaters in April 1946, with Nos 56, 74 and 245 Squadrons. A second (with Nos 222, 234 and 263 Squadrons) followed soon after. Meteor F.Mk 4s and then F.Mk 8s formed the backbone of RAF Fighter Command's day fighter units until they were replaced by Hawker Hunters from 1954, with the last Meteor day-fighter unit, No. 245 Squadron, re-equipping in April 1957. The Meteor also served in the night-fighter role, replacing de Havilland Mosquitos, and remained in use until 1957-58, when replaced by Gloster Javelins. **Jon Lake**

Making 32 deck landings on HMS* Implacable *during April-June 1948, Meteor Mk III EE337 was one of the first jets to operate from an aircraft-carrier.

Gloster Meteor Variants

F.9/40 (G.41) prototypes

Gloster received a contract (SB21179/C.23(2)) for 12 Gloster Whittle aircraft on 7 February 1941, to meet specification F.9/40. This specification number was originally used to refer to the prototype aircraft. An eventual production rate of 80 aircraft per month was anticipated, and the contract included the jigs and tools necessary to sustain this number. The Ministry of Aircraft Production signed a letter of intent for an initial 300 of the new jets on 21 June, which was confirmed on 8 August, with an official order. Simultaneously, Rover received an order for 30 Whittle engines, with future production at 20 per week.

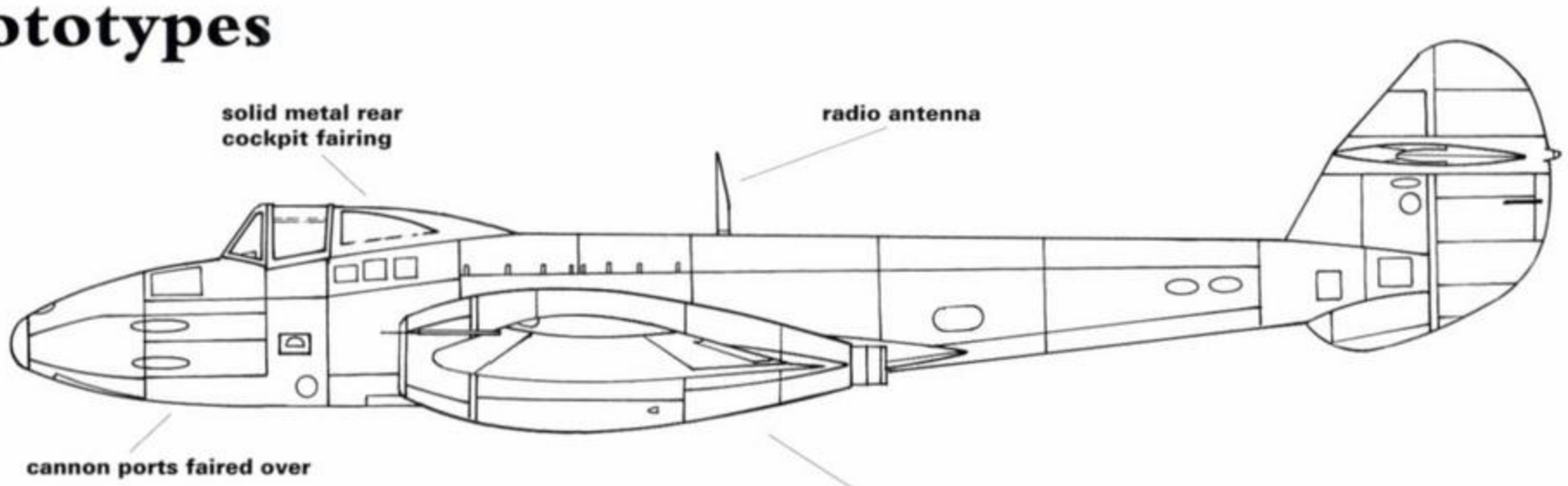
The Whittle W.2B engine was to have been built in three versions: the prototype Series I, rated at about 1,100-1,200 lb st (4.9-5.4 kN); the Series 2 with a modified diffuser, rated at 1,400 lb st (6.2 kN); and the production Series 3 (Welland I), with an 80-bladed turbine disc (instead of 72 blades) and a thrust rating of 1,500 lb st (6.7 kN).

Although only 12 aircraft were to be built initially, the demands of future production led Gloster to sub-contract much of the work. Boulton Paul built 12 sets of mainplanes and their elevators and jigs; Parnall was to have made tail units, but a Luftwaffe attack destroyed the company's drawing office, forcing Gloster to take back the work. The Pressed Steel Company built rear fuselage sections, and other sub-contractors included Bell Punch Company, Charlesworth Bodies, Excelsior Motor Radiator Company, Standard Motor Company, and Worcester Windshields. Delays meant that Gloster assumed a portion of the work originally planned for some of the sub-contractors.

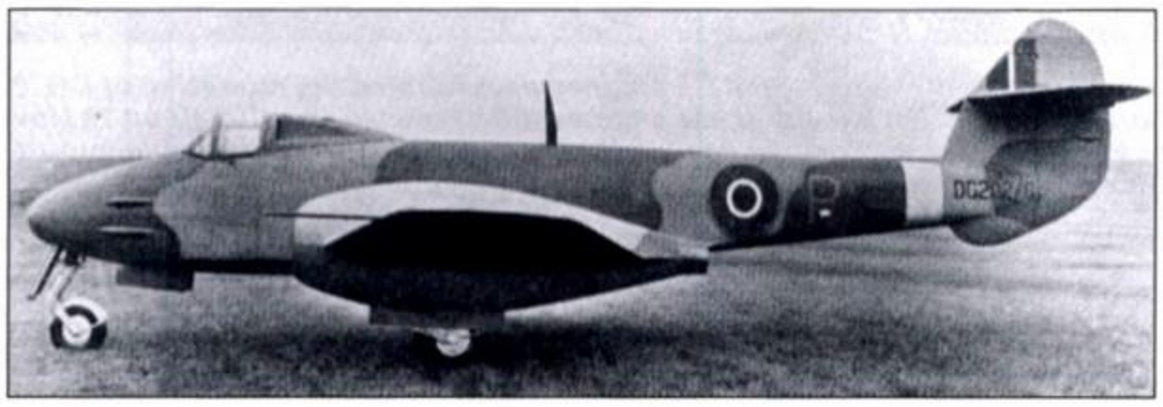
The prototypes were designed around a pair of Rover-built Whittle W.2B engines, although delays to them (principally caused by persistent surging and turbine blade failures) resulted in development being taken over by Rolls-Royce (from Rover). W.2B work proceeded slowly, resulting in the development of alternative engines by de Havilland and Metrovick (Metropolitan Vickers). The first prototype, DG202/G, was fitted with W.2B/23 engines, but they were not flight cleared. The aircraft underwent taxiing trials on the airfield on Newmarket Heath from 22 July 1942, but an attempted take-off showed that a run in excess of 15,000 yd (13716 m) would be required with the original engines, and that maintaining height would be impossible in the event of an engine failure. The situation was sufficiently serious for the Halford-engined aircraft to be accorded urgent priority, with work on the Whittle-engined prototypes virtually ceasing. More ominously, it was suggested that the Meteor would not be manufactured at all, and Gloster began work on an 'emergency jet fighter', the Ace, powered by a single Halford engine, to meet specification E.5/42. On 26 November, Meteor production was actually cancelled by the Ministry of Aircraft Production, whose patience had finally been broken by the continuing delays with the W.2B engine. The order for F.9/40s was reduced to six, while an order for three Ace prototypes was placed. Three days earlier Halford telegraphed Gloster with the news that the first of his engines had passed its tests and was being dispatched, and that a second engine would follow by 5 December.

The fifth prototype, DG206/G, powered by de Havilland's 2,300-lb st (10.23-kN) Halford H.1 engines, thus became the first F.9/40 to fly. Michael Daunt flew the aircraft (redesignated as the F.9/40H, with a 15-in/38-cm increase in centre-section span) for the first time at Cranwell on 5 March 1943. This aircraft later received a bulged fairing on the left-hand side of the centre fuselage, housing a cabin pressurisation pump. DG207/G was completed to a similar standard as the prototype Meteor F.Mk II – a proposed operational Halford-engined version to be built as insurance against failure of the Rover engines to live up to expectations.

The original engines got airborne in a Meteor on 12 June 1943, when DG205/G flew for the first time from Barford St John, in the hands of Michael Daunt, powered by


solid metal rear cockpit fairing
radio antenna
cannon ports faired over
Rolls-Royce-built Whittle W.2B/23 centrifugal-flow turbojets

F.9/40 (DG202/G)

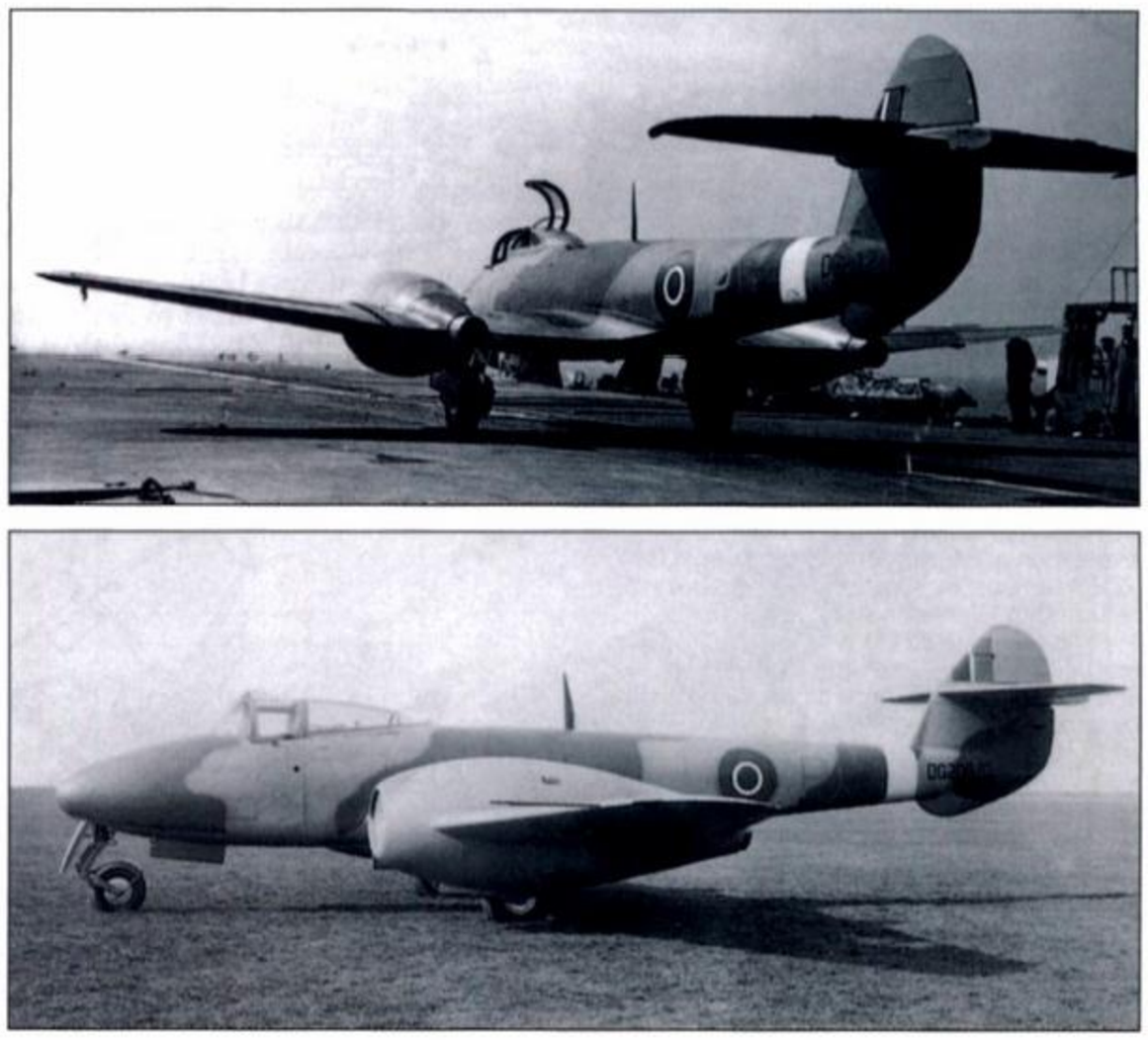


DG202/G (left), with the initially troublesome Rolls-Royce-built W.2B/23 engines, was the third of the prototypes to fly, after DG205/G, in July 1943. After 365 hours of flight testing, it suffered its first major incident, an engine explosion, on 13 December. After repair it was serviceable again in May 1945 and in August was flown to Abbotsinch for deck handling trials aboard HMS* Pretoria Castle *(below).

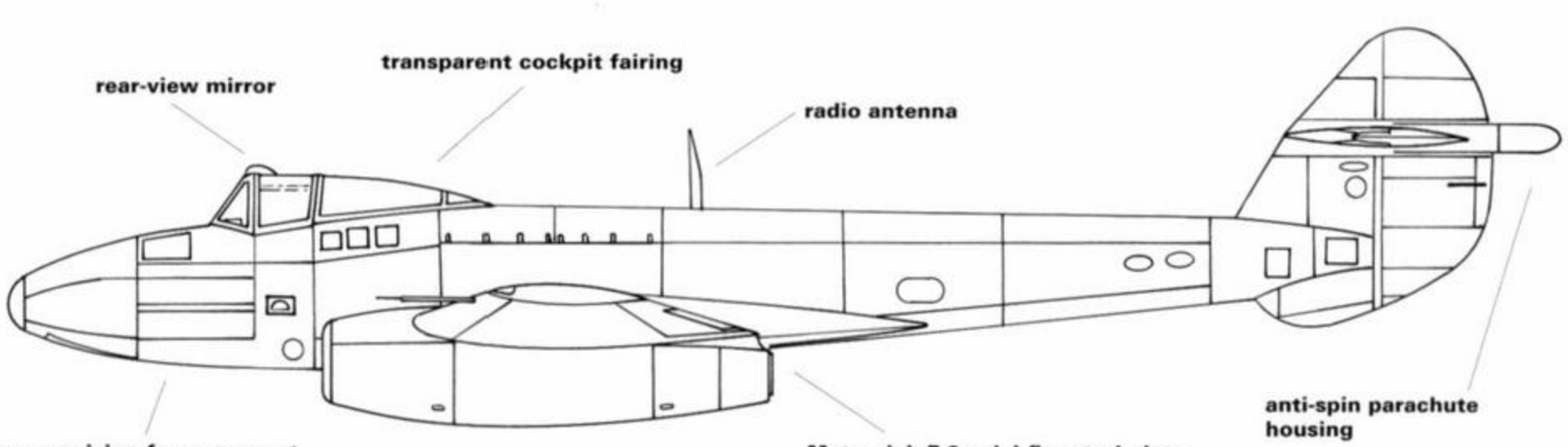
1,600-lb st (7.1-kN) Rolls-Royce W.2B/23 engines. It was followed, on 24 July, by the similarly powered first prototype, DG202/G. This flight was made by the same pilot, from the same airfield.

The next F.9/40 to fly was the third prototype, DG204/G (the F.9/40M) with 1,900-lb st (8.45-kN) Metrovick F.2 engines. These were narrower, longer axial-flow turbojets, and would not fit between the Meteor's wing spars; instead, they were accommodated in slender nacelles which hung below the wing, unlike the fatter nacelles centred on the wing chord which housed the Welland or H.1 engines. Ground tests revealed that the F.2's idle thrust was too high, so the engines were removed, modified and refitted prior to the 13 November 1943 first flight from RAE Farnborough. The aircraft was then lost, on 1 April 1944, after only three hours and nine minutes of flying time. The F.2 engine formed the basis of the later Beryl (which powered the SR/A.1 flying-boat fighter), which was in turn developed to become the Sapphire, one of the great post-war jet engines.

Quite apart from the different engines, the Meteor prototypes differed from one another in various other small respects. DG202/G had a deeply dished solid fairing behind the canopy, and had no tailplane/tailfin acorn fairing. DG203/G, with Power Jets W.2/500 and later 1,760-lb st (7.8-kN) W.2/700 engines, became the main aerodynamic evaluation aircraft, and also introduced the pressure cabin. Some sources suggested that the aircraft was also fitted with the originally planned six-cannon armament, but this seems most unlikely. DG204/G had a clear-view fairing behind the cockpit, and a rear-view mirror in a bulge



The first of the F.9/40s to get into the air was the de Havilland-built Halford H.1-engined DG206/G, flown by Michael Daunt on 5 March 1943. Note the fully transparent rear portion of the cockpit canopy, fatter engine nacelles and shorter jet pipes on this aircraft.

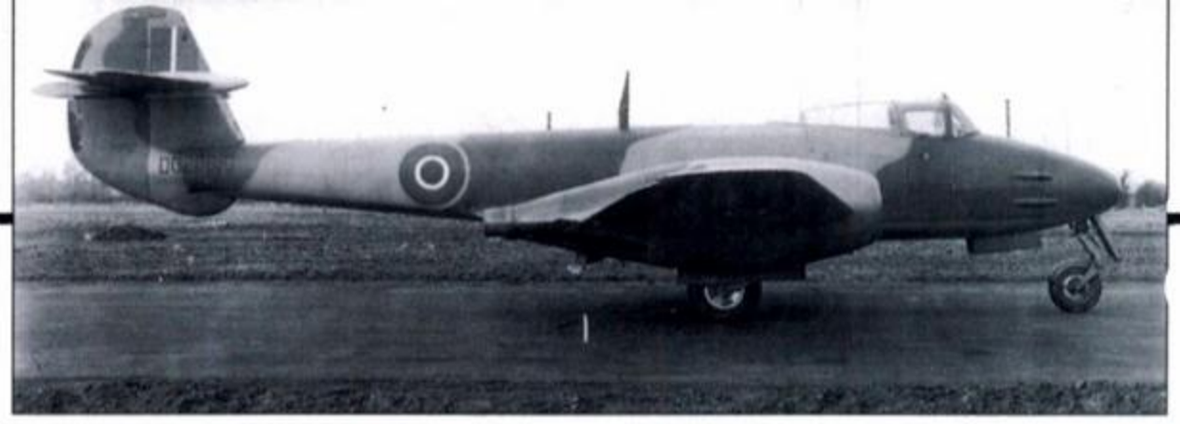


F.9/40M (DG204/G)

above the canopy itself, though as on all of the prototypes and F.Mk Is, this was still a sideways-hinging unit. DG205/G, the fourth prototype, was little more than a flying shell for Rover engine testing, and not the first with airbrakes, as had once been planned. DG208/G, powered by 1,600-lb st (7.1-kN) W.2B/23 engines, was fitted with an enlarged fin and rudder. DG209/G was powered by 2,000-lb st (8.9-kN) W.2B/37 Derwent I engines, and had a tailfin 'acorn' fairing, like that fitted to DG208 with the unique enlarged fin and rudder. The Derwent I engine was essentially a Welland with Power Jets' reverse flow combustion replaced by a straight-through combustion system similar to that used in the Halford engine, and was derived from the B-26 engine developed by Rover from the W.2B.

Four further prototypes, DG210-213, were abandoned when the stop-work order was rescinded and the production order was reinstated, since the number of F.9/40s (which had been reduced from 12 to six) was increased to only eight aircraft.

Although usually referred to simply as F.9/40s, the aircraft actually had a name from February 1942, when the appellation Meteor was finally selected. Early suggestions had included Ace, Annihilator, Avenger (Gloster's early choice), Cyclone, Dauntless, Reaper, Scourge, Sky-rocket, Tempest, Terrific, Terrifier, Thunderbolt (choice of the Ministry of Aircraft Production), Tyrant, Violent, Vortex, Wildfire and Wrathful.



Above: In a bid to improve directional stability, W.2B/23-powered DG208/G was tested with a straight-edged tailfin, a larger rudder and an acorn fairing at the junction of the tailplane and fin. However, the modification proved too heavy and was abandoned. DG208 was also the first Meteor to be fitted with dive brakes.

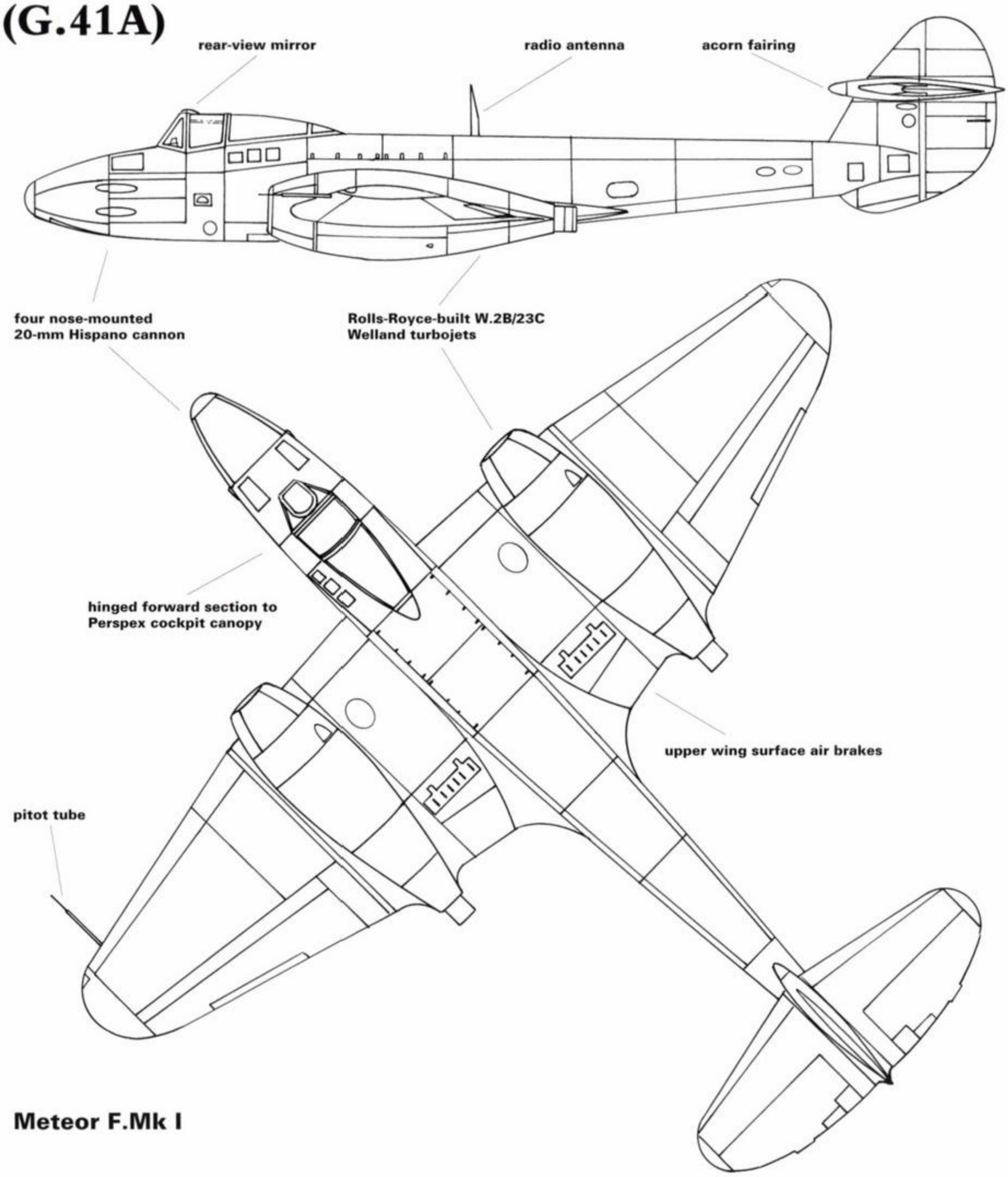
Above: Axial-flow Metro-Vick F.2 engines necessitated the mounting of DG204/G's engine nacelles below the aircraft's wing. Trials with these engines, first flown in the aircraft on 13 November 1943, were inconclusive as they were cut short by a crash in April 1944, after just three hours and nine minutes of flight testing. The aircraft had never flown above 6,000 ft (1829 m).

Meteor F.Mk I (G.41A)

After the eight F.9/40 prototypes, Gloster received Contract No. A/C1490/41, dated 8 August 1941, and built an initial production batch of 20 Meteor F.Mk Is to meet it. Some 14 went on to see active service with No. 616 Squadron. These were closely based on the Welland-engined F.9/40, with the aerodynamic refinements flown on DG209/G. The first Meteor F.Mk I, EE210/G, made its maiden flight on 12 January 1944. The aircraft were powered by Rolls-Royce-built Welland W.2B/23C engines, despite the obvious superiority of the Derwent I and Halford H.1. By May 1944, the Welland had an effective automatic start system, and its time between overhauls of 180 hours represented more than seven times the total life of the Me 262's Jumo 004, so it should not be judged a failure. The first Meteor F.Mk I, EE210/G, became the very first Meteor 'export' when, in February 1944, it was loaned to the USAAC for evaluation at Muroc; Britain received a Bell XP-59 Airacomet in return. The Meteor was returned to Gloster in April 1945. The second F.Mk I (EE211) was used as a testbed for the Power Jets W.2/700 engine, and to test the lengthened nacelles featured by late F.Mk IIIs and F.Mk 4s. EE212 was used for aerodynamic development, and was flown with no ventral fin. It eventually became the aerodynamic prototype for the F.Mk III. The first two F.Mk Is delivered to the RAF (in July 1944) were EE213 and EE214, which retained prototype-style yellow undersides initially, and were originally used for familiarisation and training, before being returned to Gloster for conversion to full operational configuration.

The first Meteor delivered to full operational standards was EE215, which much later was used for reheat development trials. The same aircraft was eventually converted to two-seat configuration, with a second seat added in the space used for the ammunition bay. The second seat was used to carry an observer during later reheat trials, and was subsequently replaced by an RAE 'Automatic Observer'. Trials demonstrated a performance improvement of between 50 and 70 mph (80 and 113 km/h), but with a rise in fuel consumption of 72 per cent at 5,000 ft (1524 m) and a staggering 132 per cent at 25,000 ft (7620 m). Rate of climb was improved by 46 per cent and take-off performance by 25 per cent. The first Meteor F.Mk I with a pressure cabin was EE223, which was used for trials of the W.2B/37 Derwent I engine.

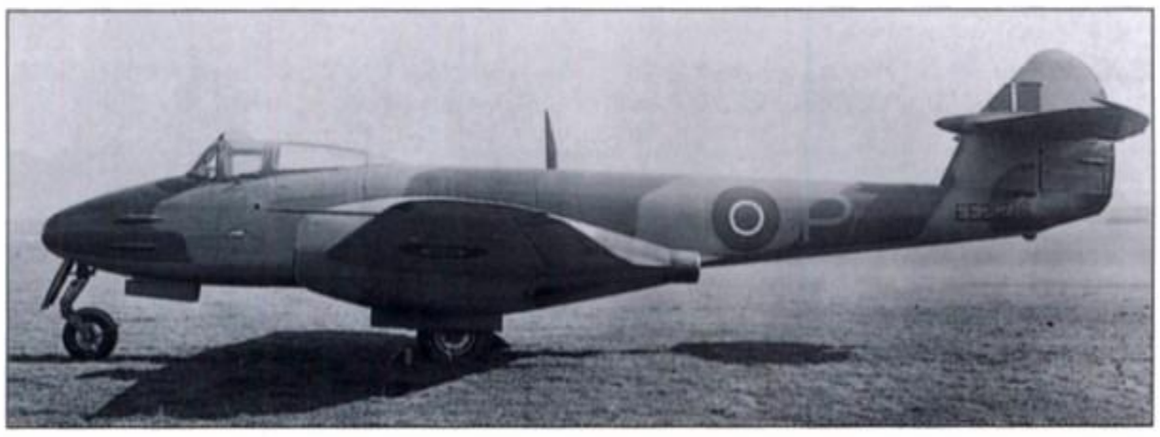
The Meteor F.Mk I had a short service life, since No. 616 Squadron started to re-equip with Meteor F.Mk IIIs from 18 December 1944, and only F.Mk IIIs were taken overseas when the squadron moved to Melsbroek and Gilze-Rijen. The type weighed 8,140 lb (3692 kg) empty, or 13,795 lb (6257 kg) (clean) equipped.



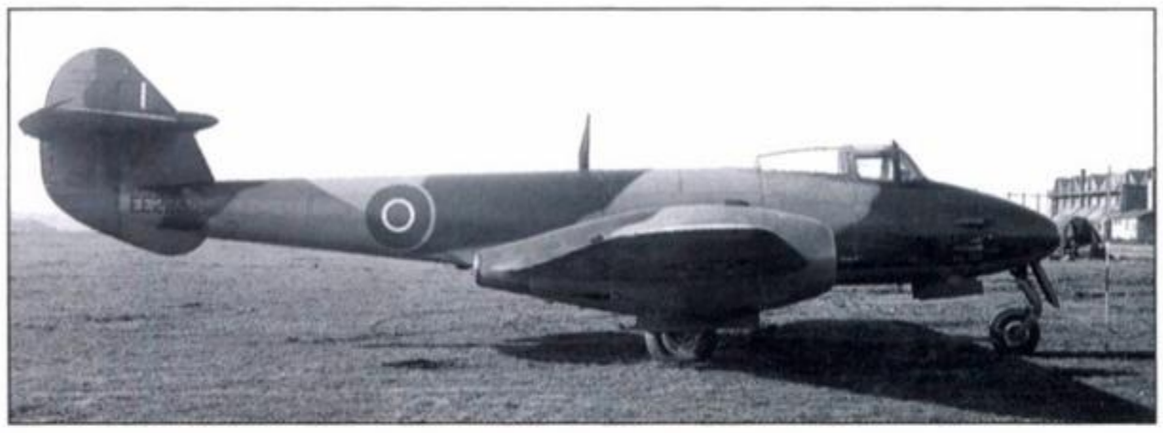
Meteor F.Mk I

Above: The seldom-seen, hydraulic oil-stained underside view of a Meteor Mk I shows its bulged undercarriage doors and retractable landing light.

Below: The third F.Mk I, EE212/G, flew on stability trials and directional stability tests, the latter involving removal of the ventral fin and a reduction in rudder area.



A number of the early Meteor Mk I aircraft ended their careers as instructional airframes. 5677M (ex-EE218), seen here at RAF Halton, was an ex-No. 616 Sqn and No. 1335 CU aircraft, and a High Speed Flight trainer.



Above: EE223/G was the first F.Mk I equipped with the Rolls-Royce W.2B/37 Derwent I engine, effectively a W.2B/23 Welland with a new impeller, diffuser and a larger turbine. To allow testing of the new engine at altitude, the aircraft was fitted with a pressurised cabin, the first Meteor so-equipped.

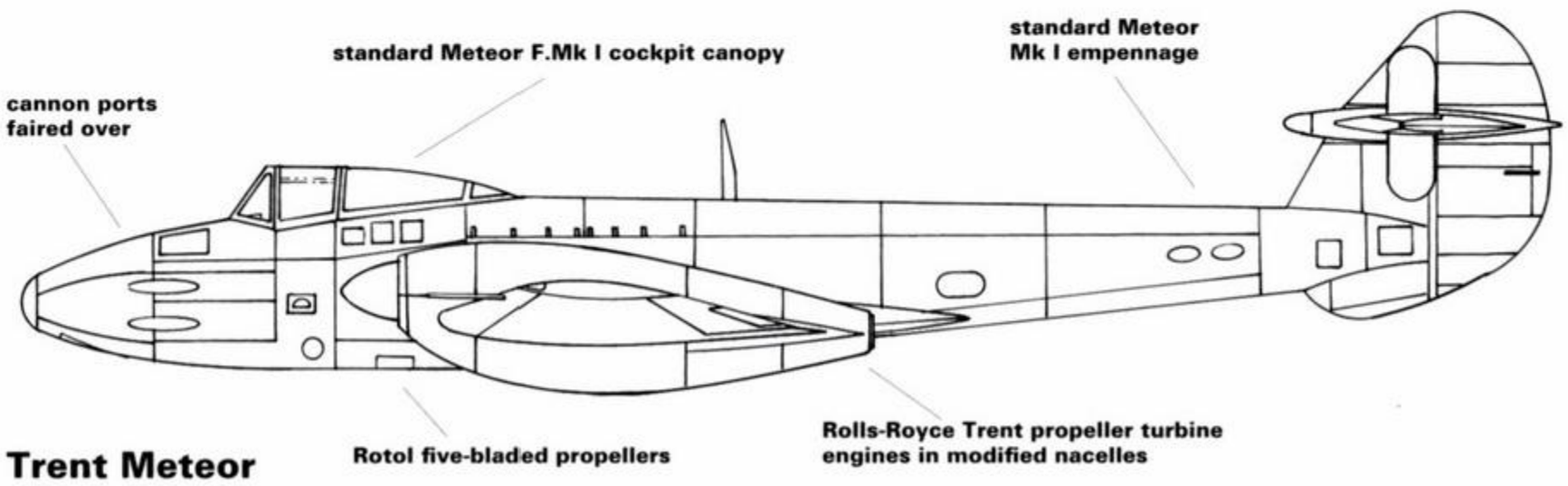
Above: Power Jets' W.2/700 engines were tested in EE221/G, the 12th F.Mk I (as they had been in EE211/G), for comparison with the Welland.

Left: Long chord engine nacelles were first flown on W.2/700-engined EE211/G, in tests carried out by A&AEE Boscombe Down aimed at raising the Meteor Mk I's limiting Mach number. Cockpit hood jettison tests followed, but by April 1945 the aircraft had been sent to an MU and reduced to instructional status.

Positioned beneath the fuselage of EE214/G is the 100-Imp gal (455-litre) ventral fuel tank first flown on the aircraft on 9 May 1944. A cure for the Meteor's somewhat limited range, this design eventually led to the development of a jettisonable tank. EE214 was later brought up to service configuration for issue to No. 616 Squadron as a trainer.

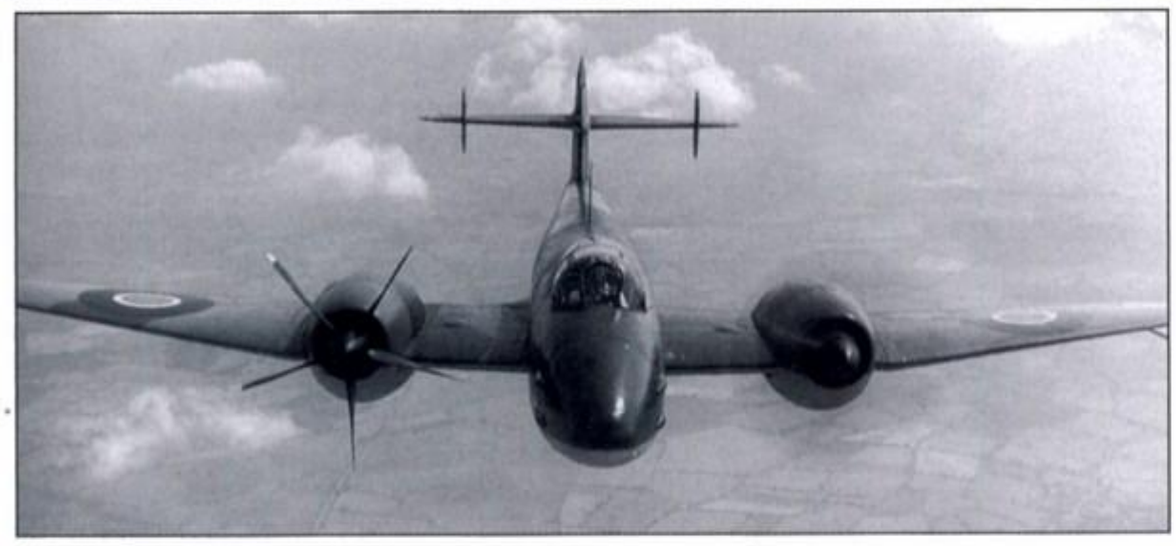
Trent Meteor

One of No. 616 Squadron's operational Meteor F.Mk Is, EE227, was used for directional stability trials from December 1944, when the F.Mk Is gave way to F.Mk IIIs. The trials aircraft flew with the top of the fin and rudder removed, then, after their restoration, with auxiliary finlets on the tailplanes. Dr A. A. Griffith of the RAE (who had earlier pioneered the axial-flow compressor used in the Metrovick F.2 engine) had long been interested in the possibility of jet engines whose turbines would drive an airscrew, while also producing some thrust. This was the genesis of the turboprop and, to validate the concept, several Derwent engines were modified to become Trent turboprops.


standard Meteor F.Mk I cockpit canopy
standard Meteor Mk I empennage
cannon ports faired over
Rotol five-bladed propellers
Rolls-Royce Trent propeller turbine engines in modified nacelles

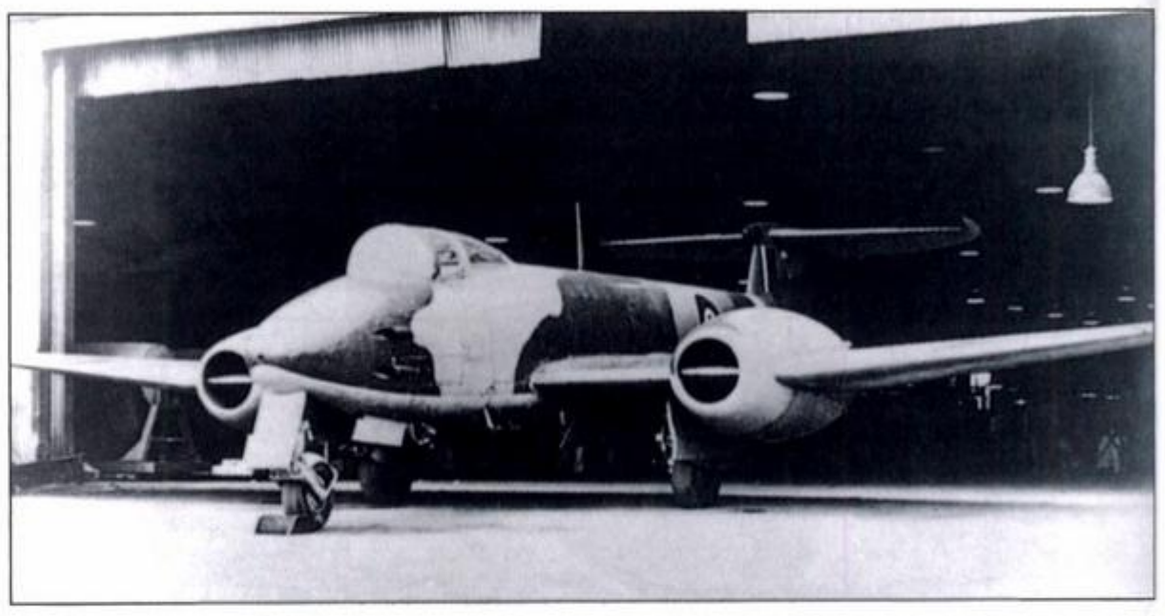
Trent Meteor

Left and below left: The diameter of the Trent Meteor's Rotol propellers was clearly limited by their proximity to the ground, even with the aircraft's lengthened undercarriage legs. Five blades were necessary to provide sufficient thrust from these diminutive airscrews. Here, EE227 cruises with its starboard propeller feathered. During landing, after the first flight on 20 September 1945, pilot Eric Greenwood throttled back, only to see the propeller blades go into zero pitch, as normally selected during engine start-up. The aircraft naturally began to drop alarmingly and it was only Greenwood's quick reactions in applying power that saved the aircraft from a crash. Thus, the Trent proved useful in attempts to solve the problems surrounding turboprop engine and propeller control.



Driving a five-bladed, 7-ft 11-in (2.4-m) diameter propeller through reduction gearing, the Trent produced 750 shp (560 kW) and 1,000 lb st (4.5 kN) of thrust. Two of these engines were fitted to EE227 (which also received a longer-stroke undercarriage for increased prop clearance), the world's first turboprop aircraft. EE227 first flew under Trent power from Church Broughton on 20 September 1945, in the hands of Eric Greenwood. The aircraft demonstrated a maximum level speed of 470 mph (756 km/h), not far short of the speeds reached by more conventionally-powered Meteors.

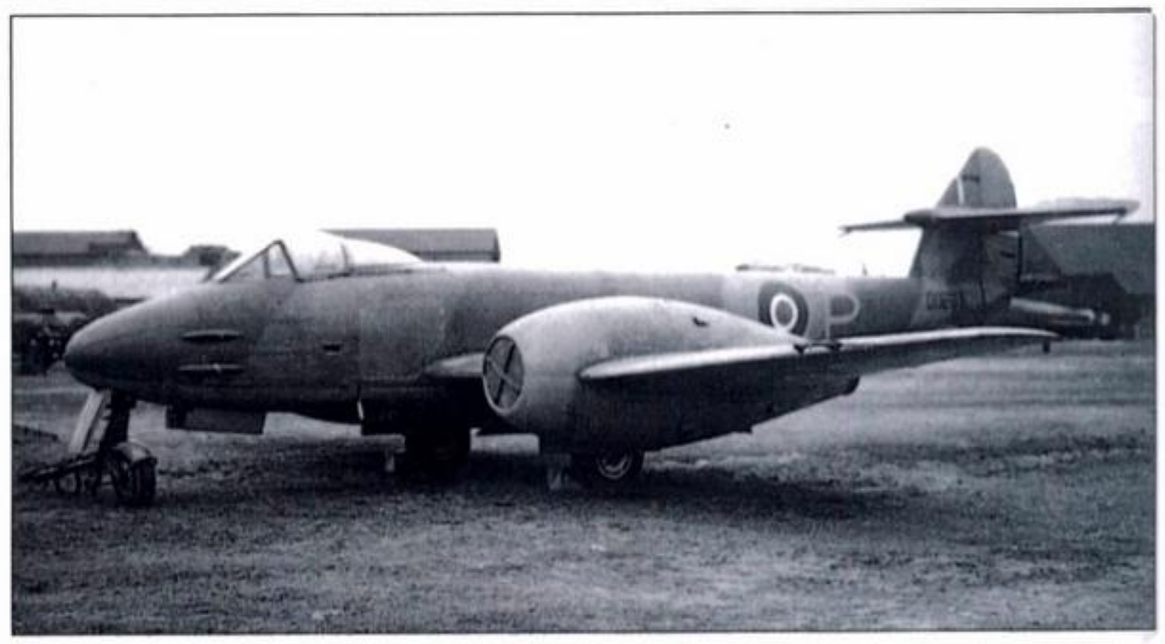
Below: Before its re-equipment with Trent engines, EE227/G, seen here in late 1944/early 1945, was flown from Farnborough with this abbreviated tail fin.



Meteor F.Mk II (G.41B)

Planned as an intermediate type due to delays with the Rover W.2B engine, the de Havilland Halford H.1 (later Goblin)-engined F.Mk II (G.41B) was at one time planned to have been the first operational Meteor variant. Gloster proposed building 50 for operational training and interim use, when development of the W.2B engine was at its slowest. DG207/G, one of the original F.9/40s, was built as the F.Mk II prototype, and was very similar to the fifth prototype, DG206 (similarly engined, and actually the first Meteor to fly). It differed in having an F.Mk III-type sliding canopy, strengthened spar booms, engine ribs and undercarriage pick-ups. Wingspan was increased to 44 ft 4 in (13.5 m), an increase of 8 in (20 cm), while fuselage length was reduced by 1 in (2.5 cm) to 41 ft 5 in (12.6 m). Despite this, the main fuel tank was lengthened, raising capacity from 300 to 325 Imp gal (1363 to 1477 litres). Ammunition capacity was increased to 720 rounds. Although a Halford-engined Meteor flew first, the Whittle-engined aircraft caught up and the F.Mk II was sidelined.

The Halford H.1b (Goblin) engines in DG207/G were each rated at 2,700 lb st (12 kN) and were vastly superior to any of the Welland-based engines, thanks to their excellent, if elegantly simple, design that featured a single-sided compressor, single-stage turbine and straight-through combustion. The engine demonstrated its power from an early stage, with the first engine on the test-bench managing to starve itself of airflow by sucking its intake ducts flat. A later engine repeated the trick when run-up in Lockheed's first XP-80A Shooting Star, but wrecked itself when the intake disintegrated and was sucked into the compressor. The Meteor F.Mk II prototype finally made its maiden flight on 24 July 1945, at Gloster's Moreton Valence airfield, in the hands of John Grierson. The RAF was unwilling to see the precious Goblin engines diverted from the Vampire, then showing great promise, and the planned Meteor Mk II production was abandoned.



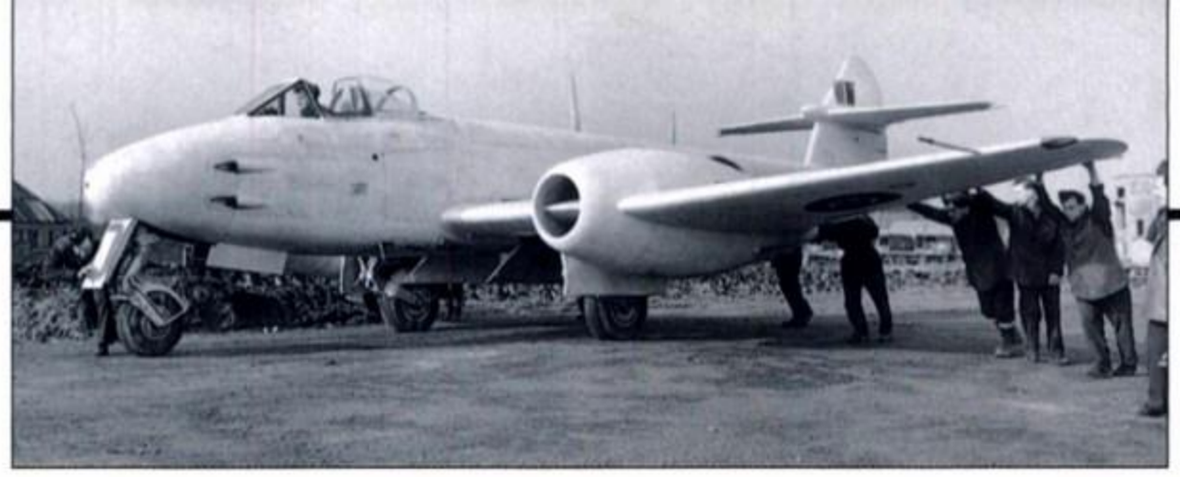
The F.Mk III-type sliding cockpit canopy fitted to the Mk II prototype may be seen here, along with the broader engine nacelles characteristic of the Halford engine. The Goblin, as the H.1b was eventually named, powered de Havilland's own jet fighter design, the Vampire.

Meteor F.Mk III (G.41C)

Gloster built 210 Meteor F.Mk IIIs under Contract 6/ACFT/1490 C.B. 7(b), in a single large batch, in two versions. Like the production Meteor F.Mk Is, the first 15 Meteor F.Mk IIIs (designated G.41C, and serialled EE230-EE244) were powered by 1,700-lb st (7.6-kN) Rolls-Royce-built Welland W.2B/23C engines, although the type had been designed to take advantage of the extra thrust of the Derwent I engine. They thus differed from the F.Mk I only in having a rearward-sliding canopy in place of the original sideways-hinging unit, and in introducing a vastly improved windscreen, reportedly developed after examination of a captured Fw 190. The aircraft also had slightly increased internal fuel capacity, and were fitted with perforated 'slotted' airbrakes.

EE230, the first of the Welland-powered F.Mk IIIs, made its first flight three months after D-Day. The principal difference between the Mk III and the Mk I was the new sliding cockpit canopy and redesigned windscreen. Allocated to A&AEE, EE230 finished up on ground gun-firing trials in June 1947 and was written off in May 1949.

The first to fly was EE230, on 11 September 1944, and EE231 was delivered to No. 616 Squadron on 18 December 1944. Several of the G.41Cs (including EE223) were subsequently retrofitted with Derwent I engines which had a shortened jet pipe and an oil-cooler vent on the starboard side of the top part of each nacelle. They were usually visible only on the starboard engine, or if the aircraft was viewed from the front, behind or above. The early Meteor F.Mk IIIs (apart from the prototype) all went to No. 616 Squadron, and most subsequently served with No. 1335 Conversion Unit.



Left: No. 616 Sqn, the pioneer Meteor unit, began F.Mk III operations in early 1945. The flight of four aircraft sent to Belgium in January included EE239, 240 and 241, all of which were finished in overall white.

Below left: This unusual rear view of EE236/'YQ-H' shows well the design of the Meteor's tailplane, which remained largely unchanged until the Mk 8.

Below: One of a sequence of well-known Charles Brown colour photographs taken at B.158/Lübeck, this image shows the standard RAF day-fighter camouflage scheme applied to No. 616 Sqn's Mk IIIs.

Meteor F.Mk III (G.41D)

From EE245 (the 16th aircraft in the first sub-batch of 25 Meteor F.Mk IIIs) the aircraft were fitted with full-standard Derwent I engines, rated at 2,000 lb st (8.9 kN). The G.41D also introduced provision for a 100-Imp gal (455-litre) underfuselage ventral fuel tank. Some later G.41Ds could carry a larger 180-Imp gal (818-litre) tank, and some had a new gyro gunsight.

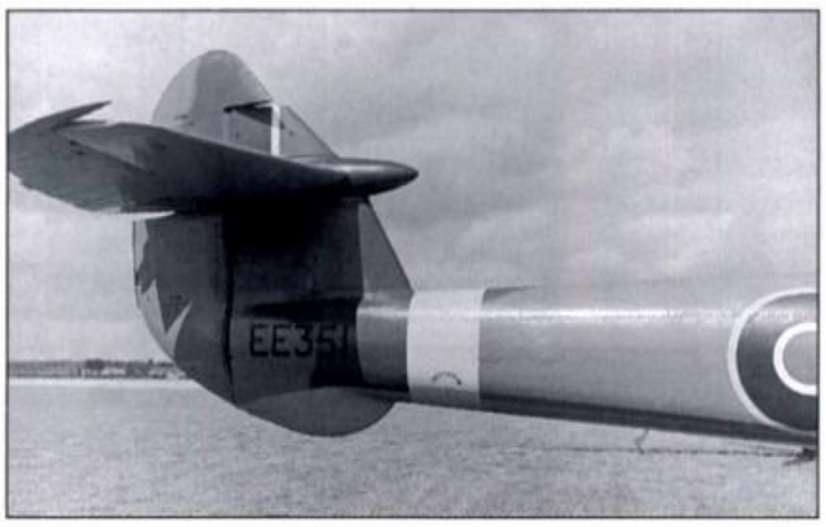
Derwent-Meteor F.Mk III production consisted of 195 aircraft, EE245-EE254, EE269-EE318, EE331-EE369, EE384-EE429, and EE444-EE493.

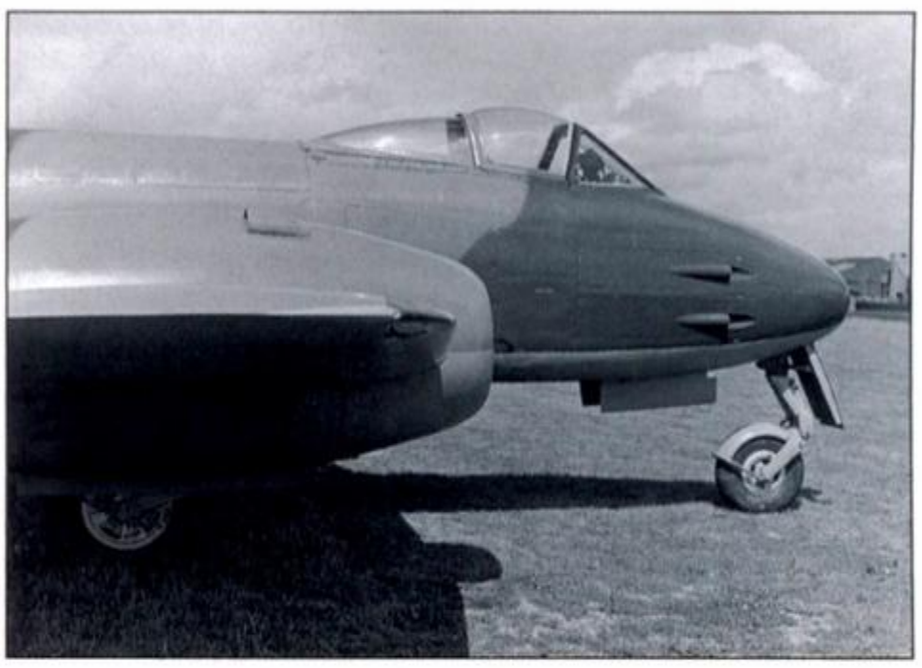
The 195 Derwent-powered Meteor IIIs rapidly became the most important aircraft in RAF Fighter Command. A handful served with Nos 616 and 504 Squadrons before these wartime units disbanded or redesignated, and were used to re-equip fighter wings at Bentwaters (Nos 56 (previously 124), 74, and 245 Squadrons), Boxted (Nos 222, 234 and 266 Squadrons), Duxford (Nos 66 and 92), Horsham St Faith (Nos 222, 257 and 263), Tangmere (Nos 1 and 91 Squadrons), and the auxiliary No. 500 Squadron at West Malling.

Large numbers of individual F.Mk 3s were also used for test and trials duties. One Meteor F.Mk III (EE445) was fitted with a 'blown' Griffith wing, using a modified Derwent 3 engine to provide bleed air for the boundary layer control system, and another (EE249) was used for high-altitude trials. EE389 was fitted with a nose-mounted inflight-refuelling probe and undertook trials with a Flight Refuelling Limited Lancaster tanker.

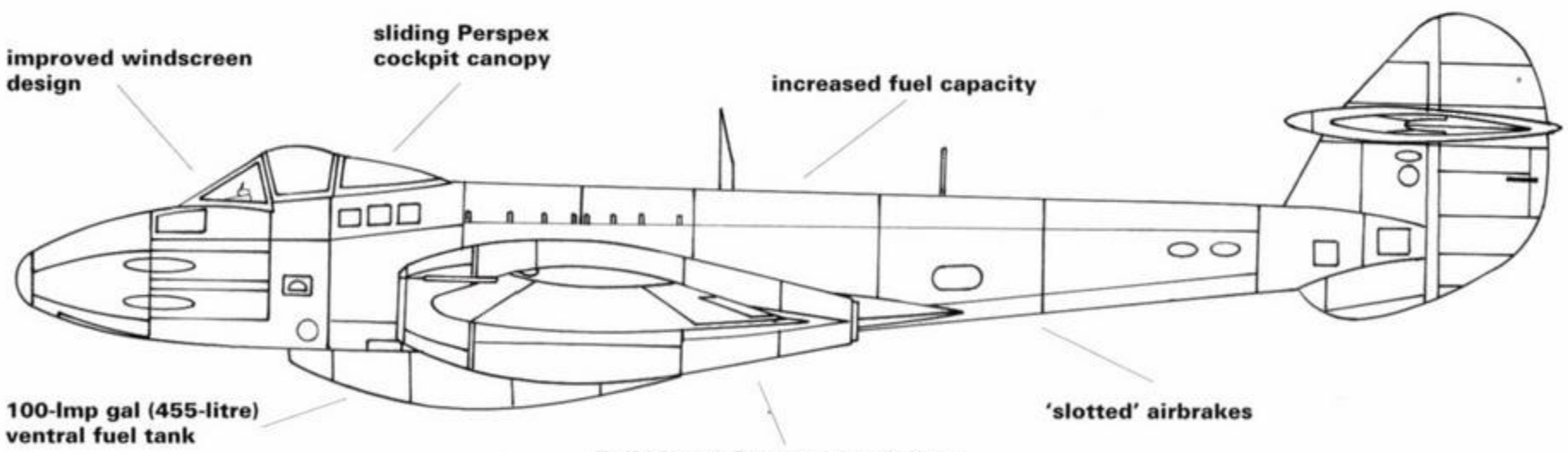
In September 1945 EE311 went to Canada for winterisation testing in the hands of the RCAF; another Meteor F.Mk III (EE429) was sent to South Africa in March 1946 for tropical trials, returning in July 1949. Another (EE395) had already been delivered to New Zealand in 1945, becoming NZ6001, and INST147 in 1947. A final F.Mk III 'export' (EE427) was sent to Australia, where it was reserialled as A77-1 in February 1947.

Below: Though a variety of revised tail designs was test flown by Meteor Mk Is, the basic empennage as fitted to the first F.9/40 remained basically unchanged until the Mk 8, save for the acorn fairing between fin and tailplane.



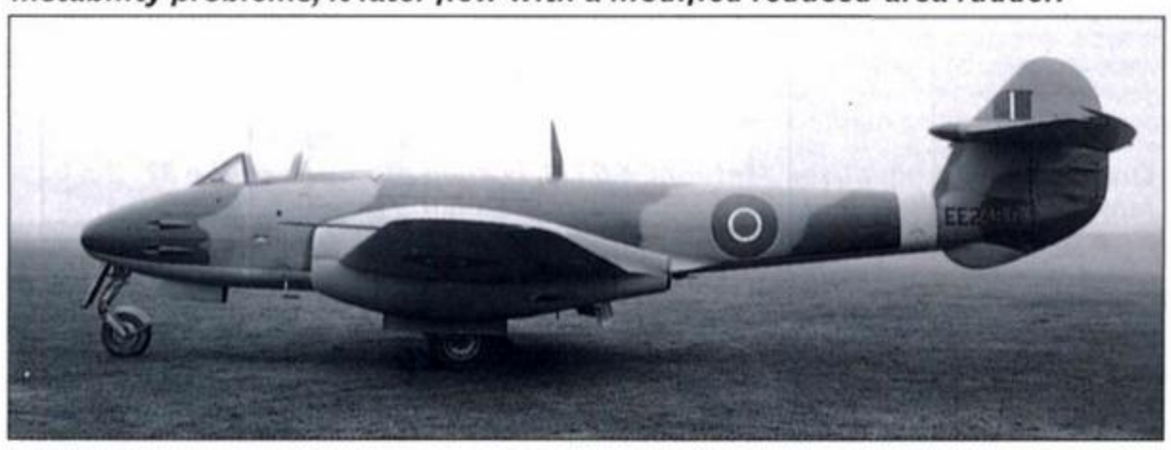


Above: A characteristic of the Derwent-engined Mk III was the oil-cooler vent on the starboard side of the top part of each nacelle, clearly visible here.



Meteor F.Mk III (G.41D)

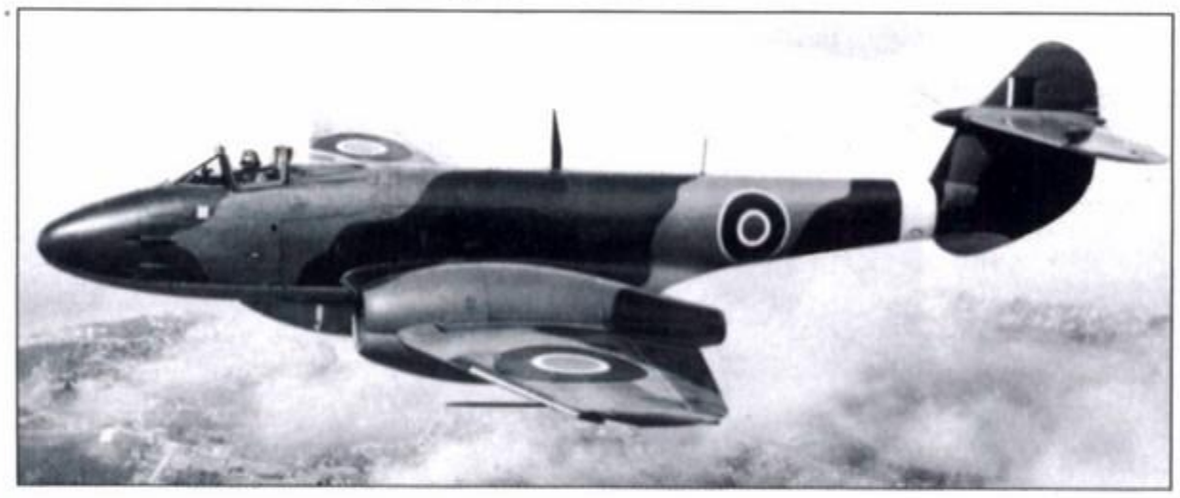
The fifth Derwent-powered Mk III off the production line, EE249/G was re-engined with Power Jets W.2/700 and fitted with a pressurised cockpit for high-altitude trials. As part of the effort to cure the Meteor's directional instability problems, it later flew with a modified reduced-area rudder.



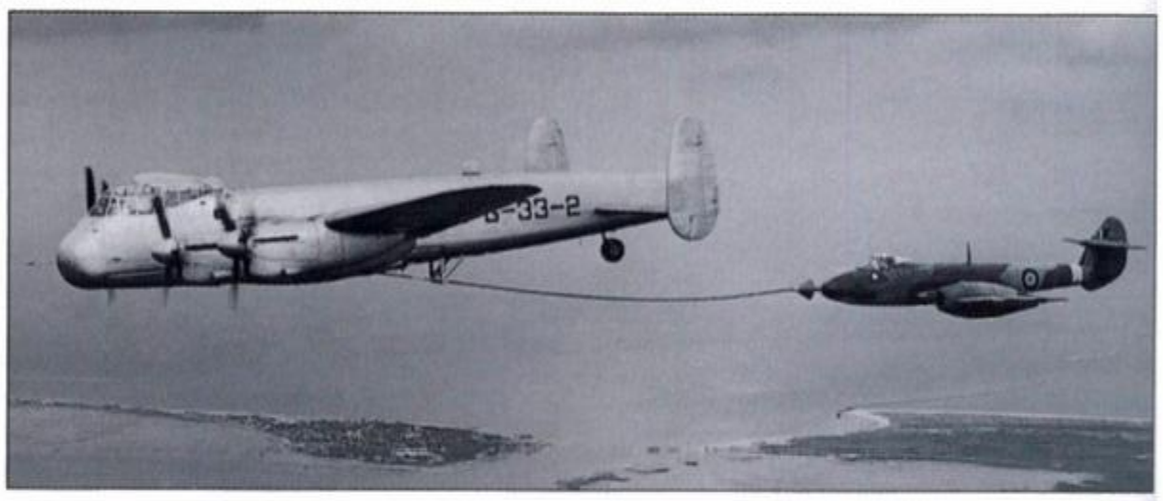
The AI radar set intended for the Meteor NF.Mk 11 was fitted in a crude nose radome in F.Mk III EE348 by the Central Radar Establishment and tested in 1946 by the Central Fighter Establishment. Here it is seen at RAF Boxted in August 1946, with 'ZQ' Fighter Interception Unit codes. The FIU was absorbed by the newly formed CFE in 1944.

Above: In its second incarnation as a Meteor operator, No. 616 Sqn flew F.Mk 3s as an RAuxAF unit, from 1949. Of note are the long-chord nacelles on the nearest two of these three machines.

Below: Shipped in November 1945, EE395 was the first jet aircraft in New Zealand. With RNZAF serial NZ6001, it was demonstrated nationwide by Sqn Ldr R. M. McKay, RNZAF and flown by no fewer than 56 service pilots. Purchased by the RNZAF for £5,000, it became an instructional airframe in 1950 and was eventually scrapped in 1957.



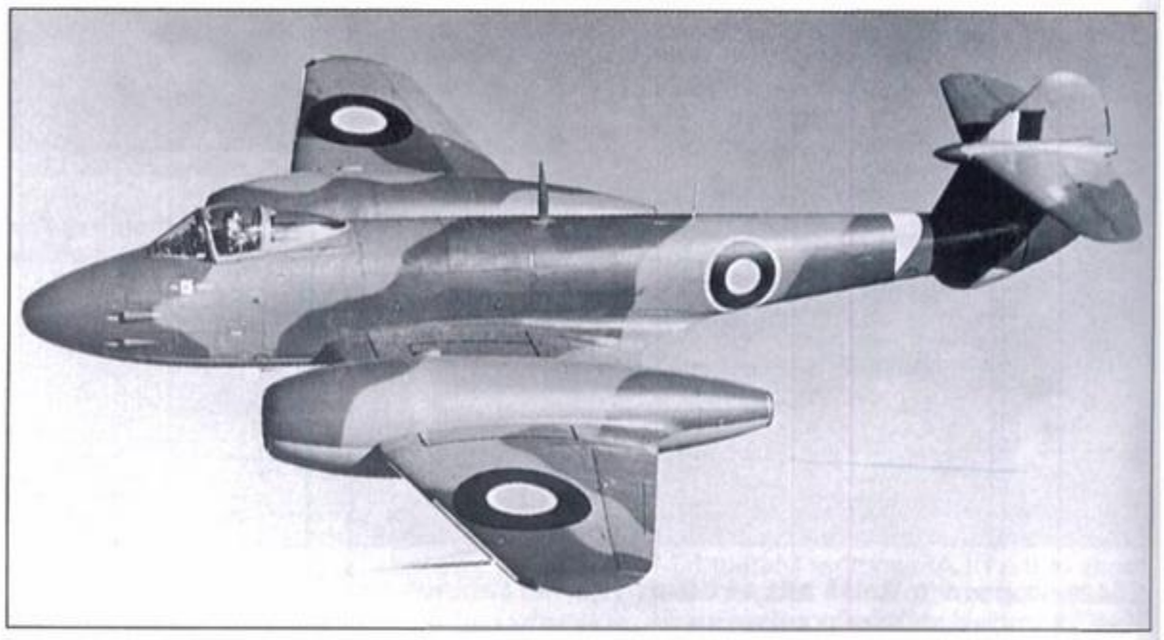
EE389 was the first Meteor involved in inflight refuelling trials, in April 1949. Here it is seen, with its airbrakes deployed and probe clearly evident (above), about to refuel from Lancaster Mk III tanker G-33-2 (ex-PB972) on 6 August (below), the day before setting a jet aircraft endurance record of 12 hours, three minutes. The neat probe installation (left) in the nose of the aircraft served as the basis of a similar fitting applied to a number of Mk 4s and Mk 8s.



Meteor F.Mk III (G.41E)

It was discovered that the Meteor's original short-chord nacelles tended to cause buffeting at high speeds, so to reduce this, and to reduce drag, longer nacelles were developed. They imposed a small weight penalty, while the longer jet pipes also incurred an efficiency loss, but were considered to mark a useful improvement. The last 15 production Meteor F.Mk IIIs (EE479-EE493) were therefore fitted with longer-chord nacelles (first tested on F.Mk I EE211, and later, with Derwent V engines, on EE360/G, which became the F.Mk 4 prototype), and were thus very similar in appearance to the F.Mk 4. The aircraft could be distinguished because they had small air extractors from the oil coolers, positioned on top of the cowlings. The aircraft served with a number of units, alongside standard F.Mk IIIs. A number of earlier F.Mk IIIs were also retrofitted with long-chord nacelles, and some were modified to full Mk 4 standard.

EE457 was among those early Meteor F.Mk IIIs fitted with long-chord nacelles of the type fitted from new to aircraft in the EE479/EE493 batch. Though they imposed a weight penalty and were less efficient, the new nacelles went some way in reducing the buffeting problems incurred by the 'short-chord' nacelle design. The long-chord nacelle became standard on all subsequent Meteor production.



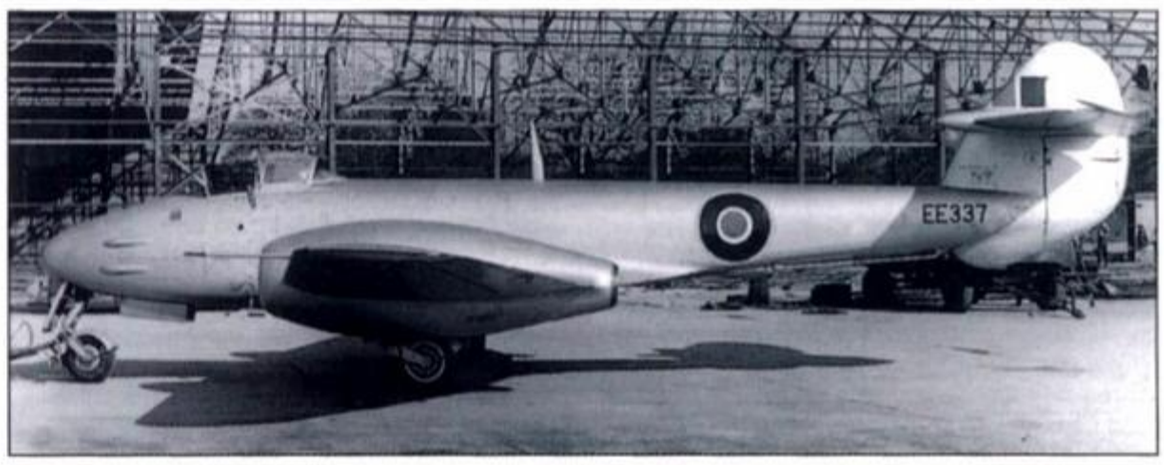
Navalised Meteor F.Mk III

Examination of the Meteor as a possible carrier aircraft began at an early stage, when the first F.9/40 (DG202/G) was used for deck handling trials aboard the HMS *Pretoria Castle* in the Firth of Clyde. The first navalised Meteor was one of two similarly modified F.Mk IIIs (EE337 and EE387) fitted with Meteor IV-type Derwent V engines (in short-chord nacelles), uprated twin-bag brakes and a Sea Mosquito/Sea Hornet 'V-type' arrester hook. Mainwheel doors were removed to prevent them striking the deck when the oleos were over-compressed, limiting maximum speed to 253 kt (270 mph; 435 km/h), though this was enough for deck landing trials. Following simulated deck landings at Boscombe Down, the two aircraft flew 32 deck landings onto HMS *Implacable* during April-June 1948. The aircraft were described as having better deck-landing characteristics than any other jet tested at the A&AEE. Originally painted in the standard high-speed silver finish, at least one of the aircraft (EE337) later received full naval extra dark sea grey and duck egg blue camouflage and full Royal Navy markings.

One of the two navalised Meteors, EE337, is seen after one of the 32 landings made on the deck of HMS* Implacable *during 1948. A&AEE Boscombe Down's report on the exercise found that pilots preferred the Meteor to other jet types with naval potential, citing better deck handling qualities. Among the modifications carried out on the aircraft was the fitting of strengthened undercarriage, with an 11½ ft (3.35 m) per second sink rate, and the limiting of gross weight to 12,000 lb (5443 kg). Contrary to normal naval practice, landings and take-offs were made with the cockpit canopy closed, such were noise levels in the cockpit.

Though of poor quality, this photograph gives a rare air-to-air view of EE337, while still in its all-over silver finish and without FAA markings.

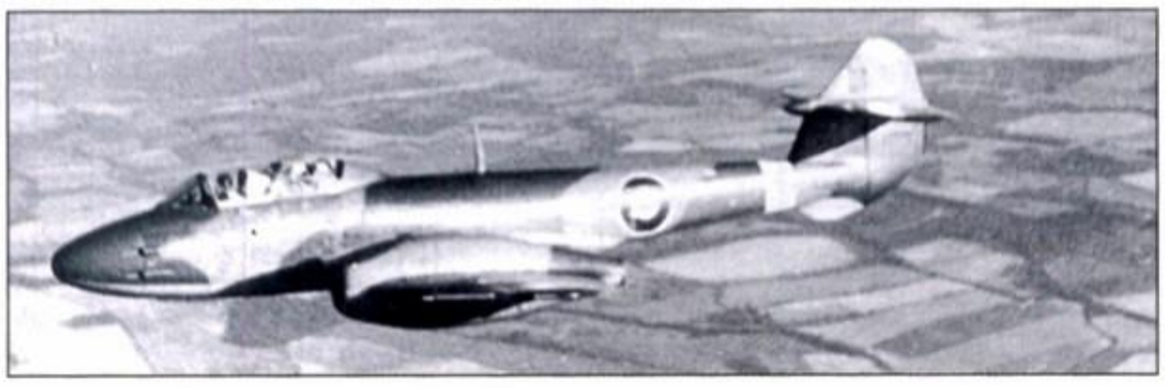
Right: Here the location of the arrester hook may be seen, beneath the rear fuselage of EE337. A V-frame hook, of the type fitted to a Sea Mosquito and Sea Hornet, was employed on the Meteor.



Meteor F.Mk III ejection seat test aircraft

Martin-Baker initially used a Boulton-Paul Defiant for ejection seat tests, but in November 1945 acquired a Meteor F.Mk III, EE416, which had a second cockpit added in the former ammunition bay, behind the normal cockpit. It had no flying controls, and was intended only to accommodate a seat under test. The modifications were conducted at Oakley, and the aircraft was delivered to Martin-Baker's airfield at Chalgrove in time for a first test ejection on 8 June 1946, and an airborne test on 24 July. A second F.Mk III, EE479, was acquired but not modified, and another, EE415, was used as a photo chase aircraft. EE338 and EE246 have been described as ejection seat testbeds in some sources, but this is believed to be erroneous, EE338 having had a second cockpit installed to allow a cameraman to be carried in support of ejection seat trials. The F.Mk III ejection seat test aircraft was replaced by a T.Mk 7 (described in the T.Mk 7½ entry) in 1952.

Below: It was from a then-fully-camouflaged EE416 that Benny Lynch made the first live ejection using a Martin-Baker seat on 24 July 1946.



Above: EE416 was later repainted, at least partially, and fitted with what appears to be a Meteor Mk 8 tailplane.

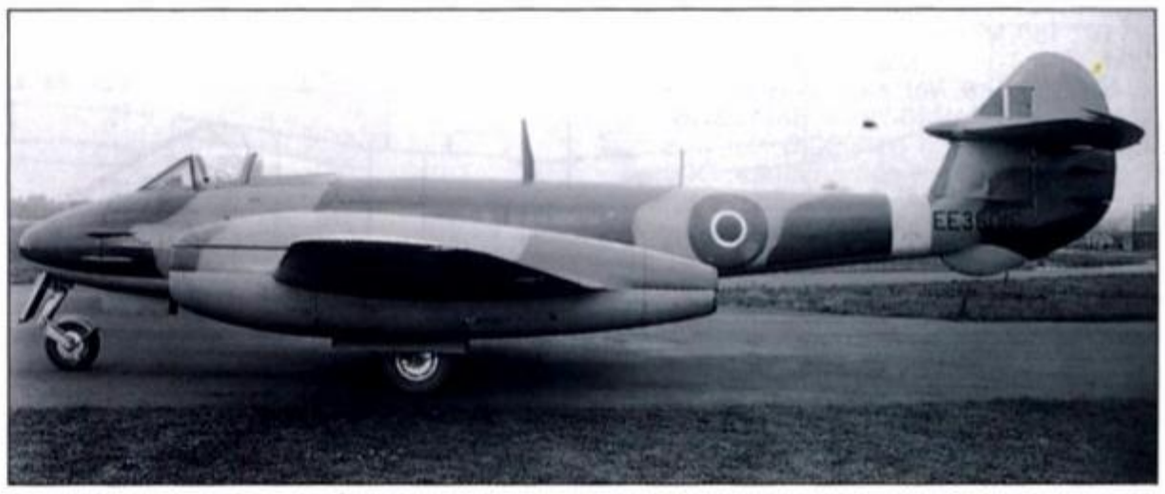
Meteor F.Mk 4 (G.41F)

The development of the 5,000-lb st (22.2-kN) Rolls-Royce Nene revolutionised post-war jet fighter development, forming the basis for a large number of the best of the early jet fighters, including the MiG-15. Gloster desperately wanted to develop a Nene-powered version of the Meteor, but was prevented from doing so by the engine's size, and by its importance to other, higher-priority programmes. Instead, Rolls-Royce redesigned the Derwent to produce what was, in effect, a scaled-down Nene – the 3,500-lb st (15.6-kN) Derwent V (Derwent 5). It offered a massive increase in thrust, from a total of 4,000 lb (17.8 kN) to a total of 7,000 lb (31.1 kN), dramatically boosting performance and improving single-engined performance, while allowing the carriage of underfuselage or underwing drop tanks without major performance penalties. Handling was dramatically improved, especially by the addition of gear-tab ailerons. The Meteor F.Mk 4 was essentially an F.Mk III with Derwent 5 engines and long-chord engine nacelles, with minor modifications to strengthen the airframe and with other minor improvements.

By the time the variant entered service in large numbers, the RAF had started using Arabic rather than Roman numeral designations for aircraft variants, so we refer to the G.41F as the Meteor F.Mk 4 throughout this article, for consistency, though it began life as the Meteor F.Mk IV.

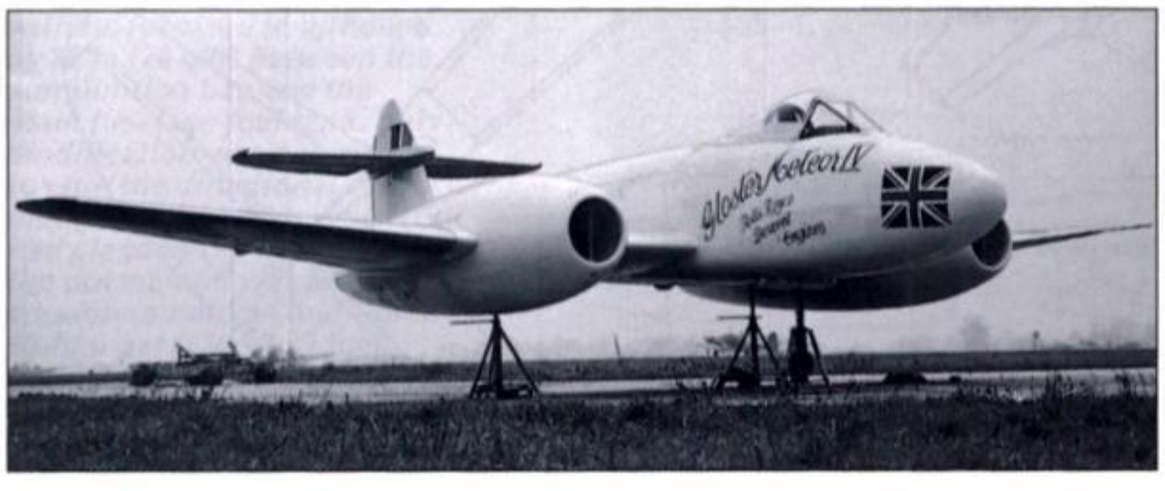
Remarkably, the importance of the F.Mk 4 has often been overlooked or understated in histories of the Meteor, perhaps because its service life was very short and it rapidly gave way to the further improved F.Mk 8. Numerically, the F.Mk 4 was the second most important single-seat version of the Meteor, and also formed the basis of the T.Mk 7 trainer.

The long-chord engine nacelles were first flown on a modified F.Mk I, EE211, in November 1944, with an extension in front of the wing, with a second extension added behind the wing later. The aircraft flew with both lengthened sections, and with 2,000-lb st (8.9-kN) Power Jets W.2/700 engines, from March 1945, demonstrating a speed



Meteor Mk III EE360 became the F.Mk 4 aerodynamic prototype upon being re-equipped with Derwent 5 engines in long-chord nacelles. It later served as trainer for the November 1945 world speed record attempts.

Sources differ as to the name given to the RAF High Speed Flight's EE455; some suggest* Forever Amber, *others the more widely quoted* The Yellow Peril. *In this aircraft, Gloster's chief test pilot Eric Greenwood attained 603 mph (970 km/h) on November 1945.



increase of 50 mph (80 km/h) at 4,000 ft (1229 m) and 60 mph (96 km/h) at sea level. The modifications permitted satisfactory handling characteristics at up to Mach 0.84, though engine thrust was the main limiting factor in level flight. EE360, a Meteor F.Mk III, overcame this limitation. This aircraft was fitted with similar lengthened engine nacelles, but also featured Derwent 5 engines, and flew for the first time in this configuration on 17 May 1945 (17 July according to some sources), effectively acting as the aerodynamic prototype for what became the Meteor F.Mk 4. The first production F.Mk 4 was EE517, which first flew on 12 April 1945. The first front-line aircraft, EE524, was delivered to No. 610 Squadron in May 1945.

Before 'real' production F.Mk 4s became available, two late F.Mk IIIs (EE454 and EE455) were taken from the production line and modified to F.Mk 4 standards for use by the reformed RAF High Speed Flight. The aircraft retained long-span wings, but were fitted with prototype Derwent 5 engines in lengthened nacelles. They were specially prepared for an attempt on the world speed record before delivery. This entailed the removal of radio masts and cannon, and the sealing of cannon ports and other apertures.

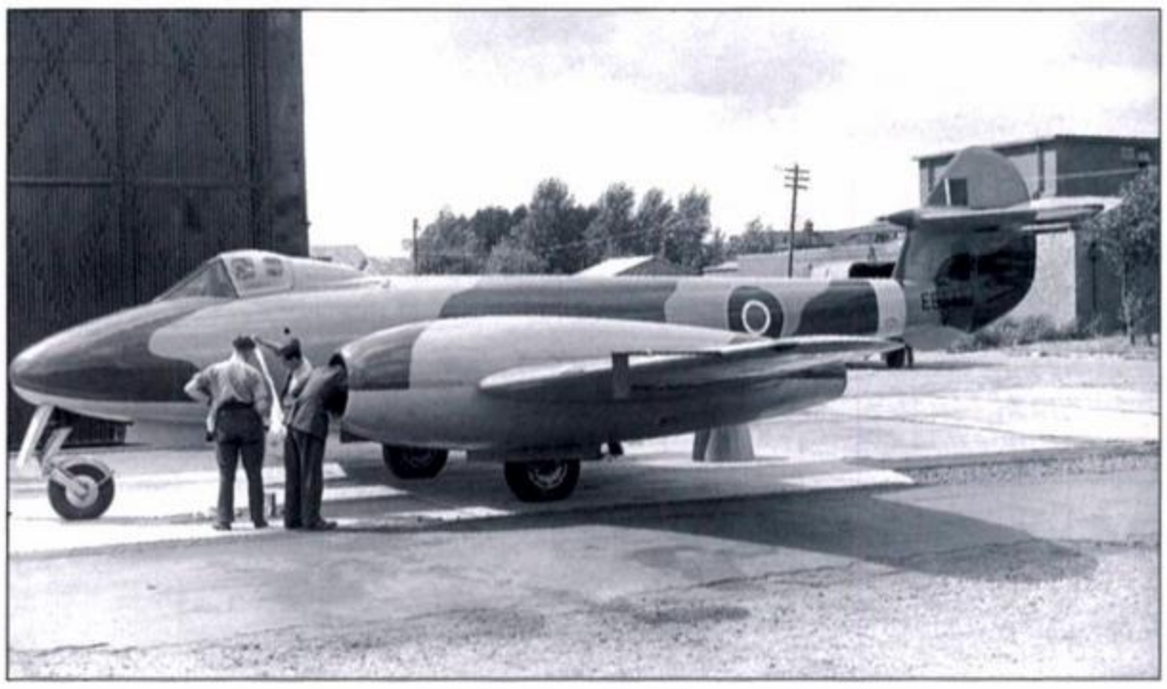
Finally, the aircraft (EE454 *Britannia* in standard camouflage and EE455 *The Yellow Peril* in overall bright yellow) were very highly polished. Operating from Manston, the Meteors flew around a figure-of-eight course which gave four runs over the 3-km (1.86-mile) measured course near Herne Bay (two in each direction) during two circuits. The aircraft flew the measured runs at 100 ft (30.48 m) over the sea (conforming with the FAI requirement to fly at less than 75 m/246 ft). The run-up to the course and the 200-ft height limit were marked by tethered balloons and anchored rubber dinghies, and a complicated system of still and ciné cameras, radar and radio was linked to the National Physical Laboratory at Teddington, where the speeds achieved were calculated. On 7 November 1945, Group Captain H. J. Wilson, CO of the ETPS, flew EE454 to an average speed of 606 mph (975 km/h) in four runs, setting a new record, while Eric Greenwood, Gloster's chief test pilot, managed 603 mph (970 km/h) in EE455. Shockwaves apparently killed nearby seagulls, but the aircraft themselves experienced only minor damage: paint was stripped from them by skin friction, and some rivets popped on EE454.

Meteor F.Mk 4 'Star Meteor'

The cropped Meteor F.Mk 4 was to have been used for an attempt to raise the world speed record above the 'magic figure' of 1000 km/h (621.26 mph) but, in the end, long-span aircraft were used instead. The RAF's High Speed Flight was reformed at Tangmere on 14 June 1946, under the Command of Group Captain E. M. 'Teddy' Donaldson, with Flight Lieutenant Neville Duke and Squadron Leader Bill Waterton. Three near-standard F.Mk 4s (EE528, EE529 and EE530) were used for practice flights, and two specially prepared aircraft (EE549 and EE550, known as 'Star Meteors') for the actual record attempts. These aircraft were even more carefully filled and polished than the previous record-breakers, and were fitted with Derwent 5 engines which had a special 4,200-lb st (18.7-kN) 'sprint' rating, available for a total life of 13 minutes, thanks to the provision of new Nimonic 90 turbine blades. The normal Perspex canopies distorted due to the heat caused by skin friction and were replaced by metal canopies with tiny Perspex 'portholes'.

On 7 September 1946, Donaldson averaged 616 mph (991 km/h) over four runs, with Waterton averaging 614 mph (988 km/h). On 24 September Donaldson exceeded 1000 km/h (621.26 mph) on one run, but was unable to beat his 616 mph average, though he did receive the first Royal Aero Club Certificate confirming a timed speed of 1001.9 km/h (622.57 mph). Waterton subsequently used EE549 to set a Le Bourget-Croydon record of 618.4 mph (995.19 km/h).

The definitive production Meteor F.Mk 4 was pressurised using bleed air and was also fully tropicalised. The addition of 3,500-lb st (15.56-kN) Derwent 5 engines increased maximum level speed by 111 mph (178 km/h), imposing extra stresses on the new variant's airframe, and especially on the wing. This became apparent when one of the early Meteor F.Mk 4s broke up when recovering from a high-speed dive, in the hands of a Gloster test pilot. This led to the development of the G.41G, with its clipped wingtips. Some of the 100 or so F.Mk 4s built with the standard wings were subsequently modified with the shorter outer wing panels.



EE549, the aircraft in which Group Captain 'Teddy' Donaldson raised the world speed record, is seen here being prepared for the attempt. The metal canopy with Perspex 'portholes' is fitted to the aircraft and its airframe has been polished to reduce drag.

Meteor F.Mk 4 (G.41G)

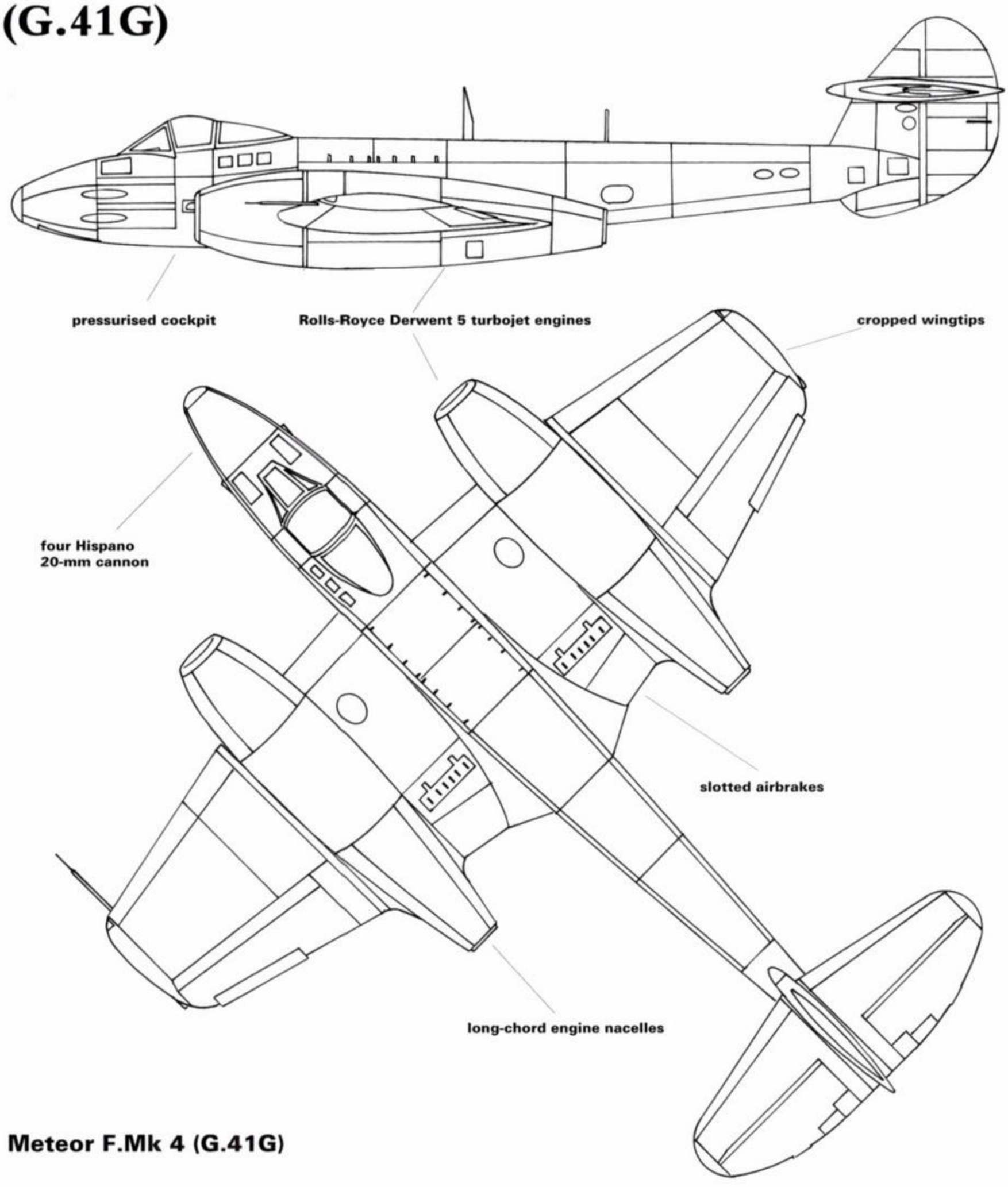
Following the fatal crash of one of the early long-span F.Mk 4s, most production Meteor F.Mk 4s were built with cropped, square-tipped wings, with span reduced to 37 ft 2 in (11.3 m). This dramatically increased the rate of roll, with little penalty, except in very-high-altitude performance. It also reduced the stresses on the Meteor's airframe, which would otherwise have required a major structural redesign, with considerable local strengthening. The cropped Meteor F.Mk 4 was designated G.41G by Gloster, and formed the bulk of the F.Mk 4s built.

Gloster built 442 Meteor F.Mk 4s to RAF contracts, comprising EE517-EE554, EE568-599, RA365-398, RA413-457, RA473-492 in Batch 1, to contract SB 1490/C.23(a), VT102-150, VT168-199, VT213-247, VT256-294, VT303-347 in Batch 2, to contract No. 6/ACFT/658C.B.7(b), and VW255-316, VW357, and VW780-791 in Batch 3, to Contract No. 6/ACFT/1389C.B.7(b), plus G-AIDC, a company demonstrator. Of the aircraft allocated RAF serials, 50 were diverted to Argentina, two to Belgium, and 12 to the Netherlands. Some 46 more F.Mk 4s were built as part of Batch 3, under the same contract (6/ACFT/1389C.B.7(b)) by Armstrong Whitworth, consisting of VZ386-429, and VZ436-437. Of these, 15 were diverted to the Netherlands, and seven (VZ420-426) to Egypt.

Meteor F.Mk 4s re-equipped most of the home defence squadrons that had previously operated F.Mk 3s, and also allowed a number of other air defence squadrons (equipped, for example, with de Havilland Hornets) to gain jets for the first time. Front-line Meteor F.Mk 4 squadrons included Nos 1, 19, 41, 43, 56, 63, 66, 74, 92, 222, 245, 257, 266, 500, 504, 600, 610, 611 and 616. After replacement by F.Mk 8s, some went on to serve with a number of training units, until about 1954/55, when they were scrapped or converted to drone configuration. Some F.Mk 4s were also converted to T.Mk 7 standards.

The Meteor F.Mk 4 was one of the finest fighters of its day, and proved popular with export customers. Some aircraft built under RAF contracts were thus diverted to foreign customers, and others were built to order. The latter are described separately.

Despite a 1945 'gentlemen's agreement' between the USA and Britain not to supply arms to Perón's Argentina, economic pressures (the need for foreign currency and a mounting debt to Argentina, which supplied 70 per cent of Britain's beef and corned beef) led to the Attlee government approving a 5 May 1947 order from Argentina for 100 Meteor jet fighters and 20 Lincoln bombers. By 1948, many expected a second (£4 million) order, for 300 more Meteors and 30 more Lincolns, to be accepted, and even for Britain to supply an aircraft-carrier, a cruiser, a destroyer and 100 more advanced jet fighters (Vampires and Attackers) in a third (£3 million) order. In



Meteor F.Mk 4 (G.41G)

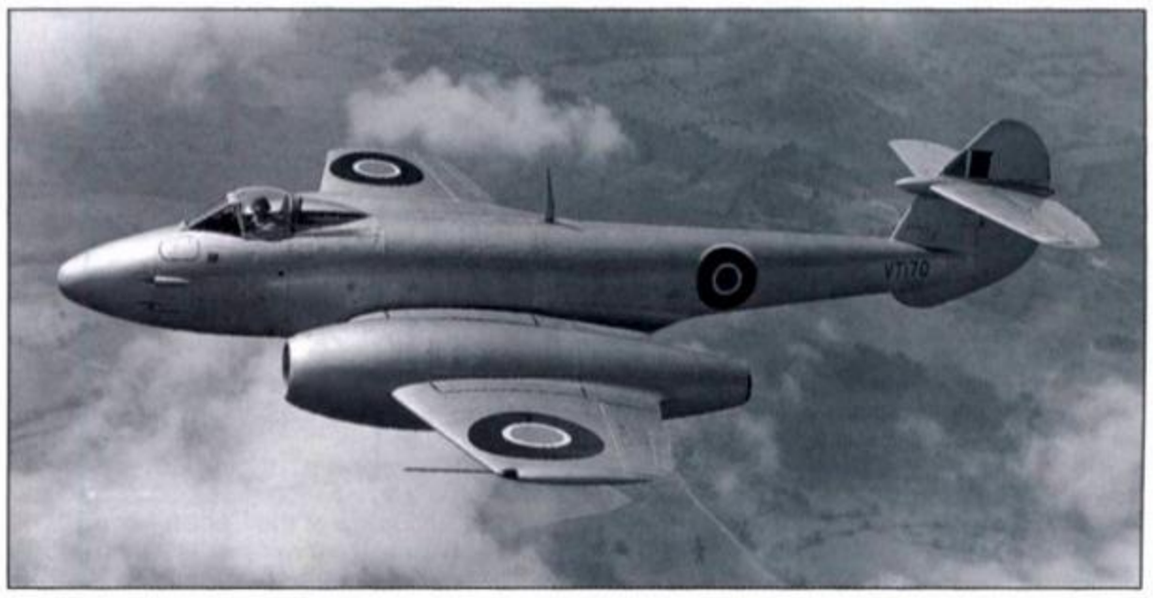
the event, growing reliance on the USA forced Britain to turn down Argentina's later requests, though the first order was fulfilled.

Argentina's first 50 Meteor F.Mk 4s were ex-RAF machines, and were the first Meteors to be commercially exported anywhere in the world. A contract was signed for 100 Meteors (the last 50 being new-build aircraft, described below), and for the training of an initial cadre of 12 pilots. The aircraft were EE526, EE527, EE532, EE533, EE534, EE535, EE536, EE537, EE539, EE540, EE541, EE542, EE543, EE544, EE546, EE547, EE548, EE551, EE552, EE553, EE554, EE569, EE570, EE571, EE572, EE574, EE575, EE576, EE577, EE580, EE581, EE582, EE583, EE585, EE586, EE587, EE588, EE589, RA370, RA384, RA385, RA386, RA388, RA390, RA391, RA392, RA393, RA395, and RA396 (respectively serialled I-042, 027, 025, 047, 044, 028, 049, 029, 048, 043, 050, 030, 046, 021, 020, 045, 024, 015, 022, 019, 017, 016, 013, 018, 026, 034, 014, 023, 036, 035, 032, 033, 037, 039, 041, 038, 031, 040, 007, 001, 008, 002, 003, 004, 005, 006, 009, 010, 011, 012). I-001 to I-050 were later reserialled as C-001 to C-050 when they were redesignated as fighters rather than interceptors. The aircraft were shipped to Buenos Aires, where the first few were uncrated, part-assembled and towed 12 miles (19 km) to El Palomar, but most were delivered in their crates to El Palomar where they were then reassembled. The Argentine Meteors fought on both sides during the revolution against the Perón regime in 1955. Despite barely adequate maintenance, 20 Argentine Meteors were still airworthy in July 1970, with 22 more undergoing repair or overhaul, including a handful (about 13) from the first batch. The Meteors were replaced by Mirage IIIs in 1971.

Two of Belgium's 48 F.Mk 4s were originally allocated RAF serials (VW316 and VW357), as were 27 (of the 61) delivered to the Netherlands as I-55 to I-81 (originally allocated VZ391, 393, 395, 396, 397, 387, 400, 388, 390, 399, VW309, 286, VZ398, 402, 409, 408, VW288, 264, 291, 310, 313, VT333, VW263, VZ394, VW295, 296 and 315, respectively). Seven of Egypt's 12 F.Mk 4s were also originally allocated RAF serials, the whole batch receiving Egyptian serials 1401-1412.

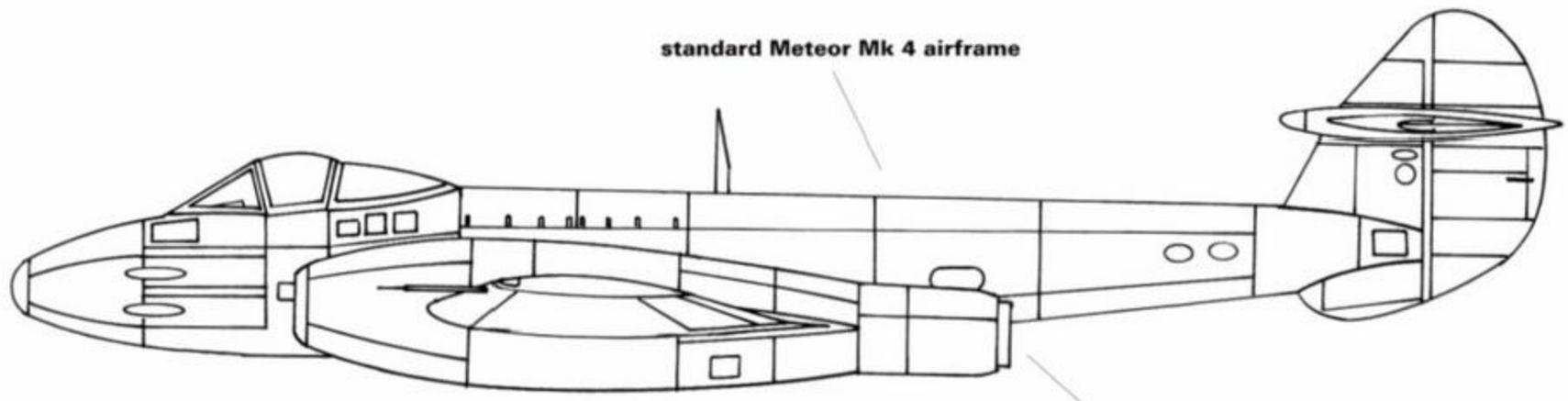
A handful of ex-RAF Meteor Mk 4s were exported as second-hand aircraft. VT196 was loaned to Canada for use at RCAF Uplands, while France received EE523 (which became F-WEPQ) and RA491.

Late Mk 4s could carry 100-Imp gal (454-litre) underwing tanks for ferry flights.

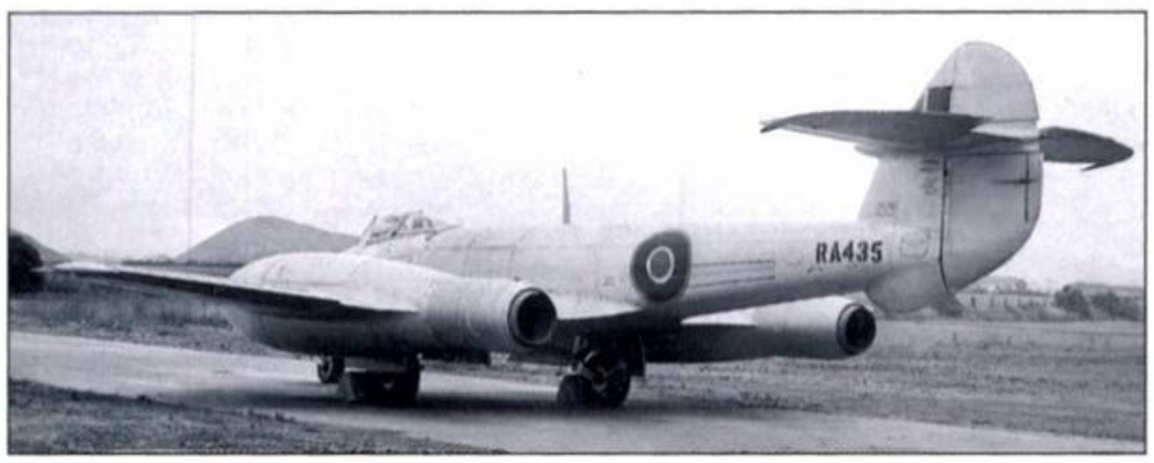


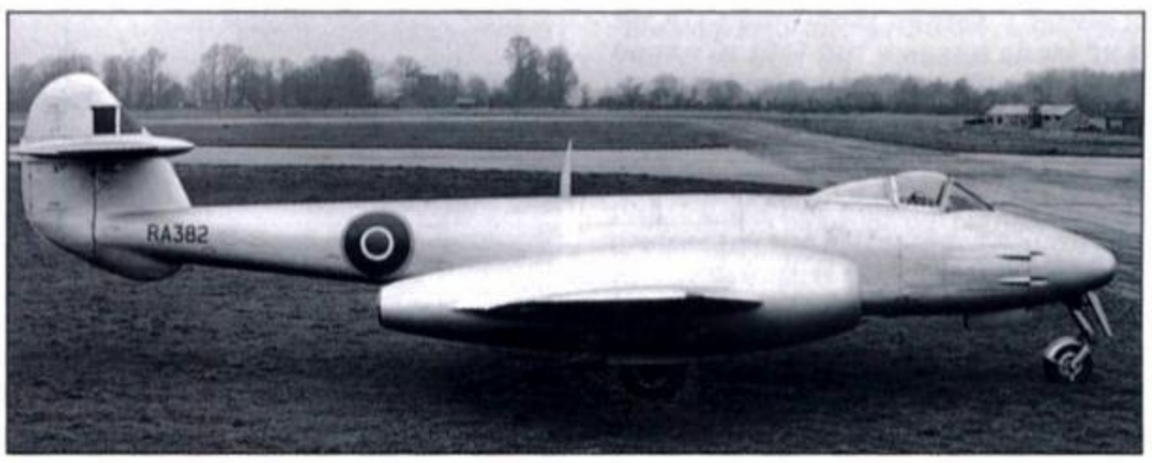
VT170 (above) and VT103 (left) are both examples from the second batch of G.41G F.Mk 4s, all serialled in the VT block. The latter machine, flown by Bill Waterton, set a world 100-km closed-circuit speed record of 542 mph (873 km/h) on 6 February 1948.

Below: Fitted with afterburners in 1949, RA435 was the first of the 'RA'-serialled aircraft to be used as an engine testbed and one of the first aircraft fitted with reheat. Originally delivered to Rolls-Royce in 1947, the aircraft was engaged in general Derwent 5 development before being equipped with afterburning Derwents. Sixty-six hours of trials, including an appearance at the 1949 SBAC show, followed, before 'RA435 reverted to standard configuration and returned to the RAF and instructional use.

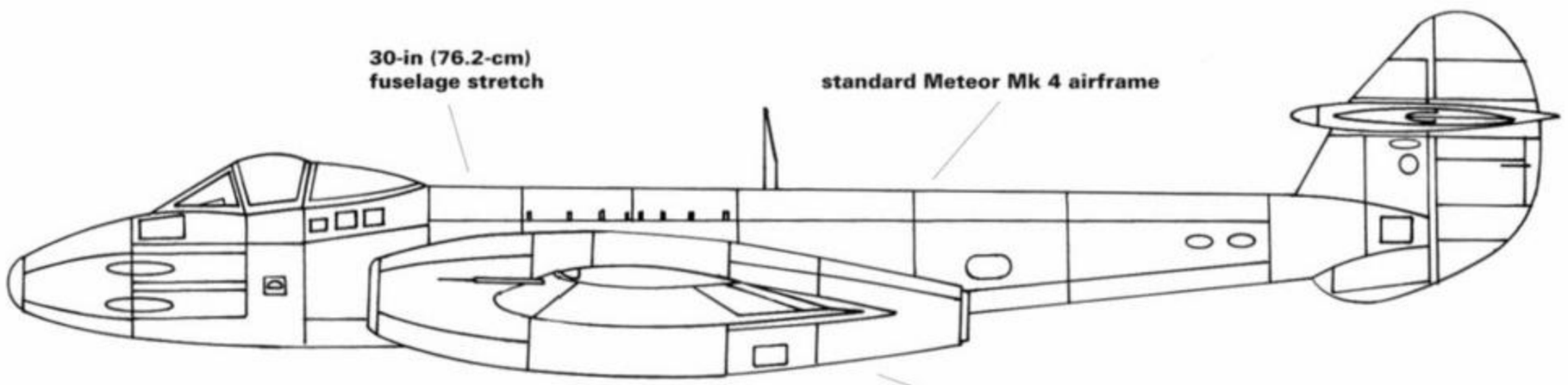


Meteor Mk 4 (RA435)



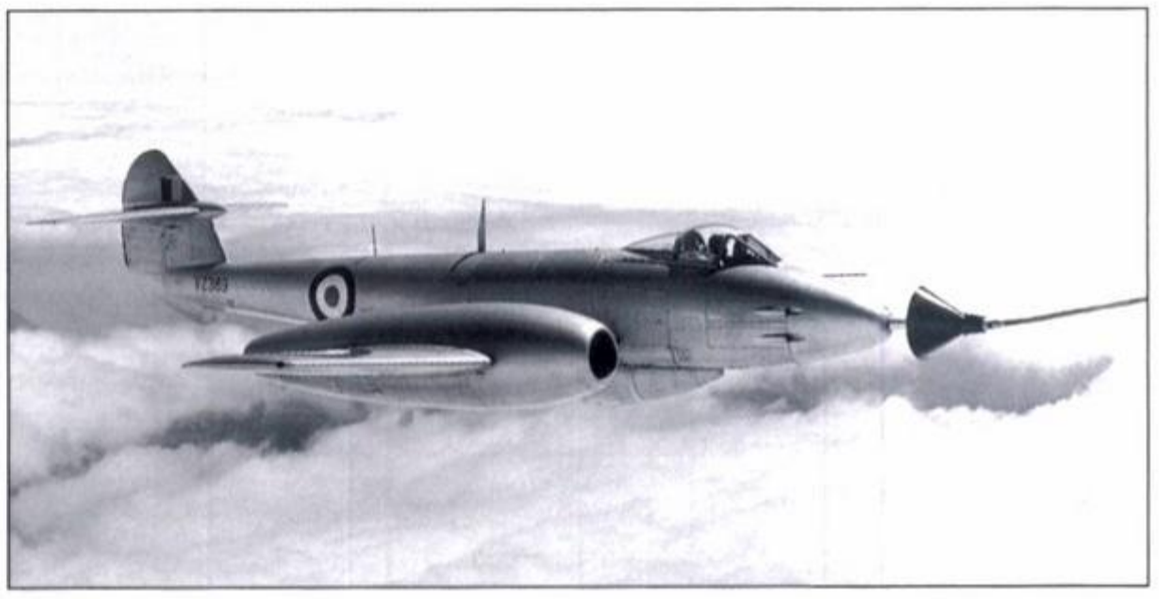


Above right: Meteor Mk 4 RA382 (sometimes referred to as the 'F.Mk VI') was rebuilt with its fuselage lengthened by 30 in (76 cm) between the ammunition bay and the main fuselage fuel tank. This modification was carried out to cure the directional instability problems which had plagued the Meteor from the outset, and was large enough to hold an additional 95-Imp gal (432-litre) fuel tank. Though not adopted for production Mk 4s, the lengthened fuselage became a feature of the Mk 8.



Meteor Mk 4 (RA382)

EE519 was engaged in testing a variety of warloads, including 95-lb rocket projectiles and 1,000-lb bombs, seen here on underwing pylons.



VZ389 was bailed to Flight Refuelling Ltd in the summer of 1949 for trials of the company's 'probe and drogue' system. The first refuelling contacts with a Lincoln tanker were made in March 1950, the pair demonstrating the system at the 1950 SBAC show at Farnborough.

Export Meteor F.Mk 4

Demand for the F.Mk 4 was intense, and large numbers were built for export, in addition to the aircraft listed above which were diverted from RAF contracts. The second batch of 50 Meteor F.Mk 4s delivered to Argentina was newly built, serialled I-051 to I-100 (later C-051 to C-100). They were given B-Class identities G-5-151 to G-5-200 for testing. There were actually two I-062s, the second being a rebuilt aircraft constructed from several crashed aircraft, including the original I-062. I-056 had long-span F.Mk III-type wings and a pressurised cockpit, and was briefly used for high-altitude research, before being written off during June 1958.

Destined to become the largest foreign operator of the Meteor, the Netherlands ordered 38 new F.Mk 4s in 1947, but received 34 new-build aircraft (I-21 to I-54) and 27 diverted from RAF contracts (I-55 to I-81). The Dutch aircraft served with the Fighter School at Twenthe, and with Nos 325 and 327 Squadrons at Soesterberg, No. 323 at Twenthe, and Nos 324 and 326 at Leeuwarden. The F.Mk 4s served until replaced by F.Mk 8s from 1951. This allowed the re-equipment of No. 322 Squadron, training reserve pilots on jet fighters, and No. 328 Squadron at Woensdrecht. A handful of F.Mk 4s lingered on as hacks, the last being withdrawn from No. 323 Squadron in June 1957.

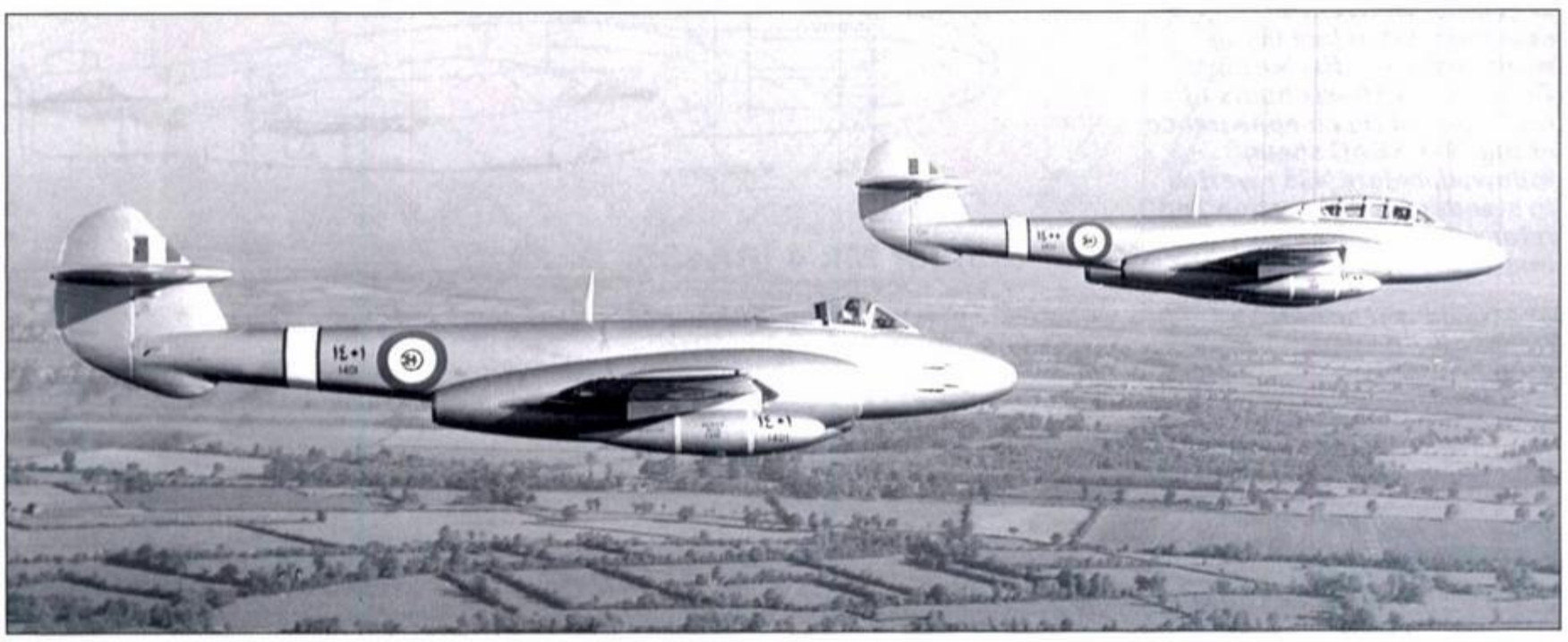
Belgium received 48 Meteor F.Mk 4s in 1949, serialled EF-1 to EF-48, 20 of which later became T.Mk 7s. The aircraft served with 349 and 350 Smaldeel, until replaced by F.Mk 8s in 1951.

An April 1948 embargo delayed the delivery of Egypt's first two F.Mk 4s until 27 October 1949 and the remainder of the 12-aircraft batch was delivered in fits and starts during 1950. Egyptian F.Mk 4s initially served with No. 20 Squadron at Almazah, and carried a desert survival pack in their rear fuselages, but were otherwise standard. The aircraft had moved to Dakhilah by 1955, and maintained a detachment at Deversoir. They disappeared from front-line service soon after the 1956 war.

The final export customer for the F.Mk 4 was Denmark, which ordered 20 aircraft for the 3rd Air Flotilla of the Danish Naval Air Arm at Karup. They were serialled 461-480 and were delivered from 6 October 1949. The 3rd Air Flotilla was absorbed by the Danish Air Force, becoming No. 723 Squadron on 8 January 1951. The F.Mk 4s of No. 723 Squadron moved to Aalborg, where they were replaced by NF.Mk 11s during December 1952, but eight served on with No. 724 Squadron (formed in 1951) until February 1957, by which time the unit also had Hunters and Meteor F.Mk 8s.

Above: Preparing for the 1949 Operation Foil air defence exercise with the RAF and USAAF, No. 323 Sqn RNAF Meteor Mk 4s get ready for a sortie from RAF Thorney Island. Dutch Mk 4s were built to RAF specifications.

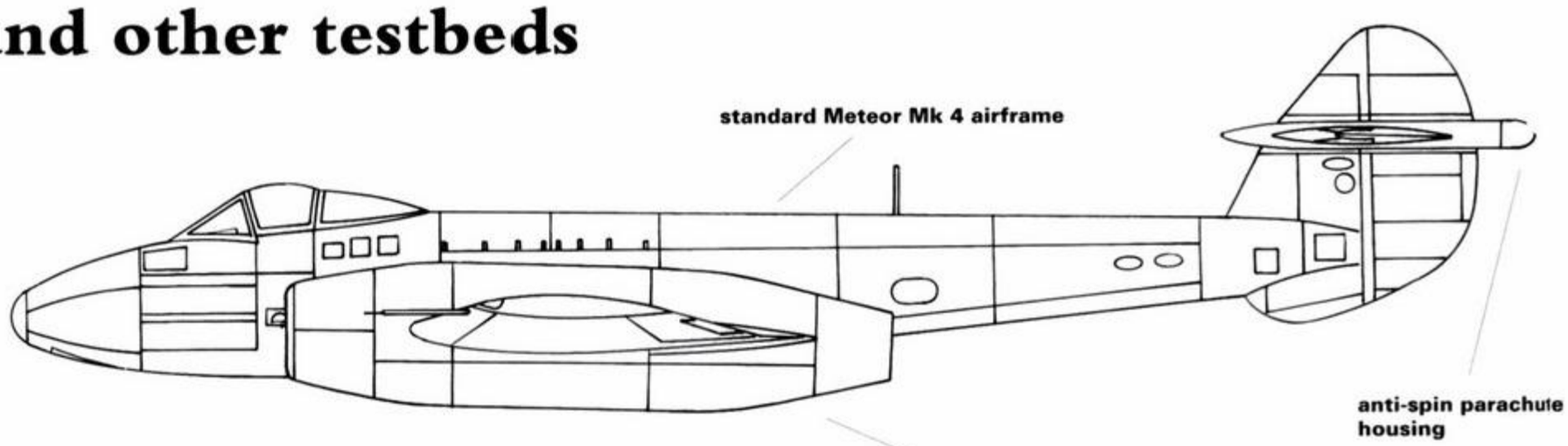
Below: After a 17-month delay, Egypt received the first two of 12 F.Mk 4s and one of six T.Mk 7s. Here the first Mk 7 (serialled 1400) and Mk 4 (1401) are seen prior to delivery. Both carry 100-Imp gal (454-litre) ferry tanks.



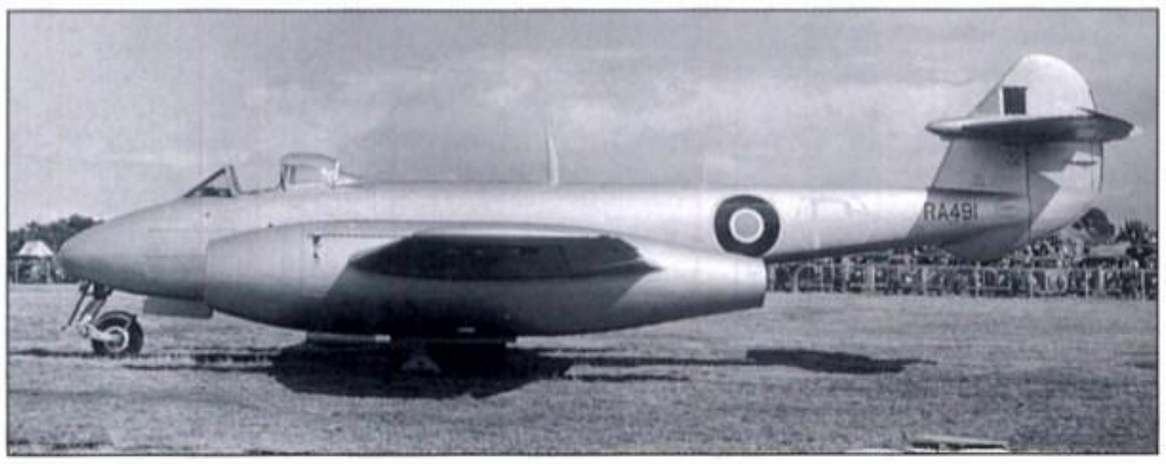
Avon Meteors and other testbeds

When the Meteor was first designed, the wisdom of using centrifugal-flow turbojets was inescapable, and the fatal immaturity of the axial-flow layout was demonstrated by the German jets. Jet engine development was remarkably rapid, however, and the disadvantages of centrifugal compressors, with their bigger diameter, began to become clear once the first practical axial-flow engines began to appear.

In retrospect, the Rolls-Royce AJ65 Avon can be seen to have marked a major step in jet engine development. Although the engine was not without teething troubles, it powered the Canberra, Hunter and Lightning, proving to be adaptable and capable of considerable development. Considerably longer than any of the centrifugal engines used by the Meteor, the



Meteor Mk 4 (RA491)



Handed over to Rolls-Royce in November 1948, RA491 was fitted with two RA.2 Avon axial-flow turbojets, with which it flew the following year, eventually racking up 42 hours of flight test time. In April 1949, uprated RA.3s were substituted and a similar number of hours flown. An attempt at the world time-to-height record was contemplated but, though practice flights took place, it was never made.

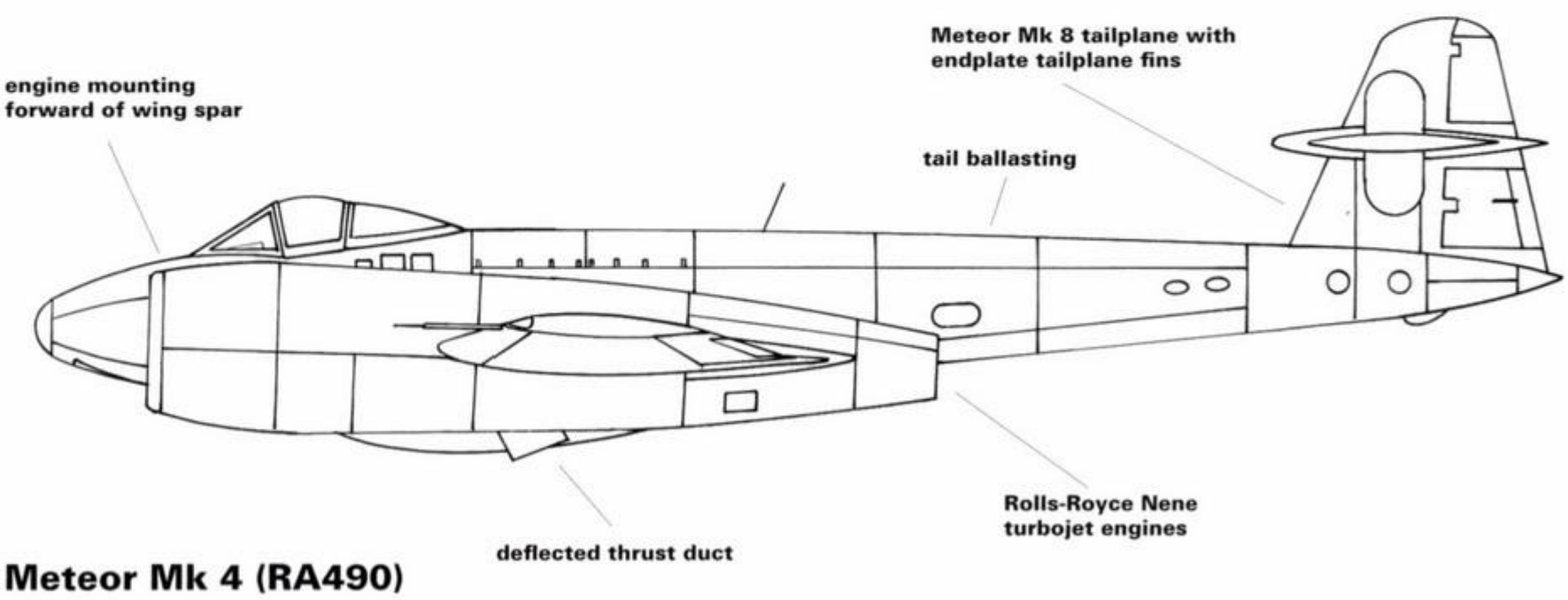
Avon was in some respects not an obvious choice of powerplant for Gloster's fighter, though the sheer performance it offered made it inevitable that it would come under consideration.

A number of Avon Meteor design studies were completed, most based on the configuration of what became the F.Mk 8, with square-cut tail unit and wingtips, and with underslung engines, with the spar looping over the top of each.

One Meteor F.Mk 4, RA491, was one of a batch of F.Mk 4s built with a modified centre-section designed to accommodate different powerplants. Sistership RA490 was used as a Metrovick Beryl testbed, but was badly damaged during the wheels-up landing which followed its second flight. The aircraft was subsequently fitted with jet-deflecting Nenes, for STOL trials, and proved capable of flying at speeds as low as 65 kt (75 mph; 120 km/h). RA491 was converted on the line to serve as an Avon engine testbed and was delivered to Hucknall in November 1948 for engine installation.

When it was no longer required as an Avon Meteor development aircraft, RA491 was sold to the French government and was used to test the French SNECMA Atar turbojet, fitted with a lengthened Meteor Mk 8 forward fuselage.

The Avon Meteor was dramatically overpowered, and any production aircraft would have had to have been extensively redesigned. Some of the design studies featured four 30-mm ADEN cannon, and most had new slab tailplanes, but the extent of the necessary redesign meant that it was more sensible to concentrate on aircraft like the Hunter and the Swift than to spend such considerable sums on the ageing 'Meatbox'.

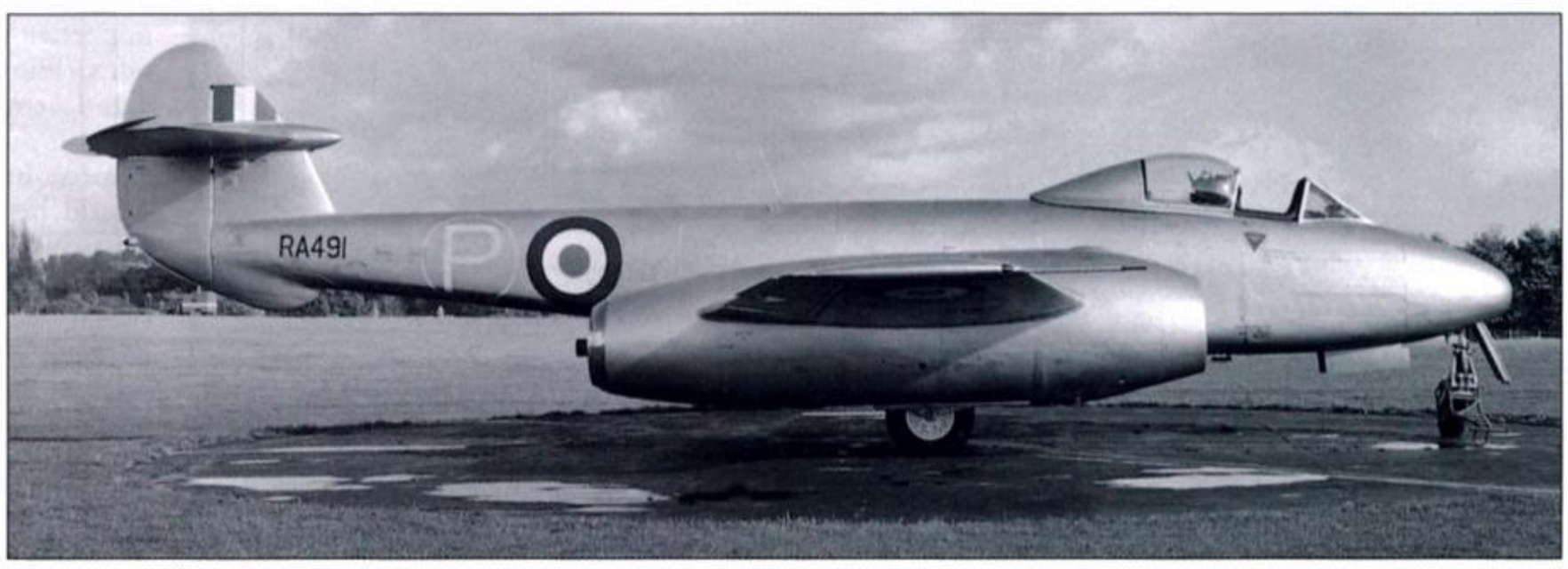


Meteor Mk 4 (RA490)

Above and right: Interest in jet deflection grew from experiments with naval aircraft with high approach speeds and centred on ways of reducing the stalling speeds of jet aircraft by deflecting their jet thrust downwards at an angle. After its wheels-up landing and subsequent repair, RA490 was fitted with two Rolls-Royce Nenes to test the concept. These were mounted ahead of the front wing spar, deflected thrust passing through a duct in the bottom of each engine nacelle. As a result, the aircraft was nose heavy and ballast was required in the tail. The tail itself was of the Meteor Mk 8 type, with tailplane endplate fins to counter lateral instability caused by the longer engine nacelles.

Left: RA490 was originally modified to flight test Metropolitan-Vickers F.2/4 Beryl axial-flow turbojets intended for the Saunders-Roe SR.A/1 flying-boat fighter. Testing began in 1947 but was cut short by an accident on just its second flight. Flown by Gloster test pilot 'Bill' Waterton, '490 suffered a hydraulic failure and Waterton was forced to put the aircraft down with its undercarriage retracted. Though it was repaired, it was immediately turned over to the National Gas Turbine Establishment (NGTE) for jet deflection experiments.

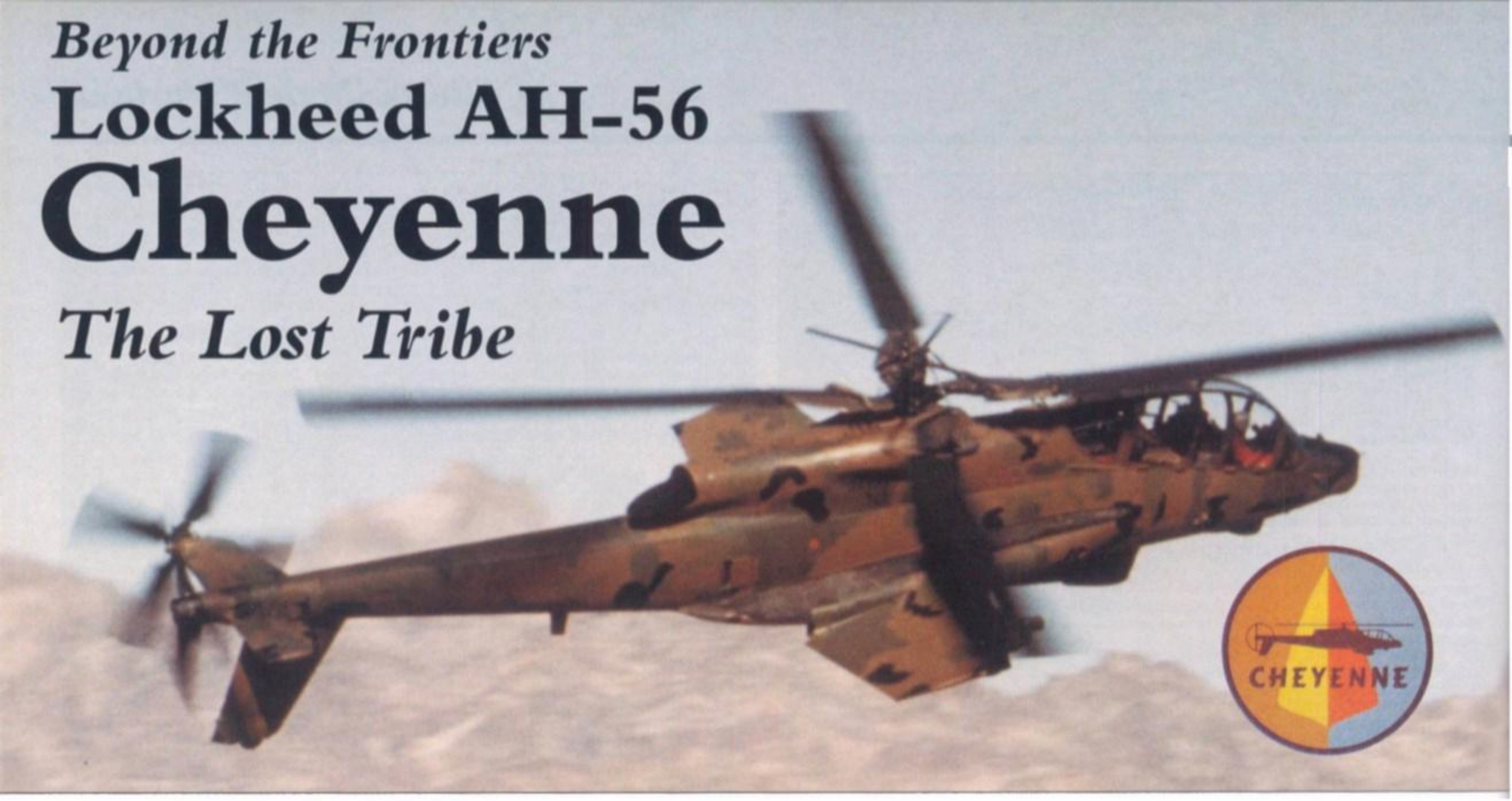
Right: After its stint with Rolls-Royce Avons installed, RA491 was sold to the French government and re-engined with a pair of SNECMA Atar 101.B21 turbojets. The work was carried out by Air Service Training Ltd in the UK and included modifications to the aircraft's airframe, including fitting enlarged engine nacelles and exchanging the original front fuselage and cockpit for those from a Meteor Mk 8. First flown in this configuration on 31 October 1951, the aircraft was later flown to France.



Beyond the Frontiers

Lockheed AH-56 Cheyenne

The Lost Tribe



The unique Lockheed Cheyenne was part helicopter, part fighter plane. Heavily armed and blisteringly fast, it promised to revolutionise the battlefield of the 1970s. In the end, it proved to be a leap too far for the politicians and Army, but it can rightly be considered to be the progenitor of today's attack helicopter.

Lockheed's Cheyenne deserves its place in history not only as the first helicopter to be designed, from the outset, as a true weapons platform, but also for the advances it made in helicopter technology. Its promise was great – offering twice the speed of any other helicopter of the time, coupled with manoeuvrability and heavy firepower. Its job was simple – to 'ride shotgun' for troop-carrying helicopters and protect them in the landing zone. Its end was controversial, as it was cancelled against a background of bitter inter-service rivalry. Yet, though the Cheyenne failed to enter service, it was not killed by any fundamental design flaws but rather by a political battle far beyond the control of those involved in the programme. The Cheyenne remains an aircraft which changed the face of army aviation and combat helicopter design forever.

The mid-1960s was a difficult time for the US military. The conflict in Vietnam was intensifying and the US found itself struggling to wage a war for which it was neither prepared nor free to fight fully. The Vietnam War changed so many of the concepts of 20th century warfare that it is invidious to highlight just one of the changes that occurred during those years. However, the most enduring symbol of the war, the Bell UH-1 Huey, also brought with it the farthest-reaching concept of that war – airmobility. In a matter of months the doctrine of the US Army became dominated by airborne infantry/cavalry tactics, using helicopters to insert troops, supply units in the field, undertake scout and medevac missions and a host of other tasks. In 1961 US Army Aviation deployed its first helicopters, Piasecki H-21B Shawnees, to Vietnam. In 1962 the first Bell UH-1As arrived and by 1964 there were 240 Hueys in-country, a number that would increase 10-fold. The Huey allowed Army units to operate in a totally new way, delivering troops and firepower with a speed and precision that freed them from traditional concepts of infantry manoeuvre. If the strategy behind airmobility in Vietnam was flawed – battles were fought and territory was taken, but not held because the troops were flown out again – there was no arguing that the tactics worked. But the tactics were also dangerous. By the end of the war, 1,213 Hueys had been lost in hostile action and another 1,380 to 'operational' causes.

Unarmed helicopters were vulnerable and, while fitting Hueys with door-mounted guns and developing gunship UH-1C/Ms were important steps forward, they were only interim ones. The Army realised that it needed a dedicated armed escort helicopter to protect its troopships. Such an armed helicopter (the term combat helicopter was still far in the future) would be capable of conducting fire-support missions for units on the ground, including those they had just escorted into the landing zone. The lessons that had been learned in the Korean War, and then forgotten, were being bitterly relearned in Vietnam. The infantry needed dedicated tactical air power, but it was not available. The provision of close air support

The original AAFSS concept envisaged the Cheyenne as an escort for the troop carriers, able to loiter over the landing zone and suppress resistance. The concept of an anti-armour helicopter came much later.

The Cheyenne mock-up exhibited few major differences from the real aircraft that followed. One exception was the underbelly turret, which originally had this swivelling mount.

This is an official pre-rollout picture of 66-8826, the first real Cheyenne, outside Lockheed's Plant 8 at Van Nuys. This aircraft was not destined to fly, however, becoming the Ground Test Vehicle (GTV), used in Lockheed's dynamic test rig.

(CAS) became a hugely contentious issue between the Army and the Air Force: the Army had the requirement but not the resources, while the Air Force had the resources, but none that truly suited the task. Fast-moving jets like the F-100 and F-105 were not designed to find small targets hidden under jungle cover, nor did they have the endurance or warload to provide the sustained CAS that the Army needed. This situation brought about the hasty reintroduction of the A-1 Skyraider to Vietnam, in US Air Force and Navy hands. The Army felt it was being penalised by its sister services (chiefly the USAF) which had always resisted the development of any organic combat aviation by the 'grunts'. Vietnam gave a whole new impetus to this requirement and, on 1 August 1964, the Army pressed ahead with its efforts to expand its airborne combat capability by issuing a Request for Contract Definition Proposals for the Advanced Aerial Fire Support System (AAFSS).

The AAFSS requirement set out a demanding set of specifications, but it is interesting to note that a fixed-wing type was never considered for the job. The Army had a serious flirtation with armed, fixed-wing aircraft in 1960/1961 when it evaluated the Douglas A-4 Skyhawk, Northrop N-156F (F-5A) and the Italian Fiat G91 – all lightweight and affordable attack aircraft. The Army was interested in 'a potential FAC and reconnaissance aircraft', but these aircraft obviously offered much more capability. The acquisition of such an 'air force' aircraft was fiercely opposed by the USAF, which brought great political pressure to bear on the project. This, coupled with the unfortunate crash of one of the two G91s under evaluation, brought an end to the Army's aspirations in 1962, and, more importantly, the Army promised to renounce all future plans to operate fixed-wing tactical jets. The fall-out from this ensured that the AAFSS would remain a helicopter, but one with unprecedented capabilities.

Attack helicopter rejected

The Army very nearly did not get that, either. On 27 March 1963 an outline specification for a new armed helicopter was submitted to the then-Secretary of the Army, Cyrus R. Vance. A memo quickly returned from Vance to the Army Chief of Staff, and opened with the words, "After most careful review and consideration, I have concluded that the marginal military advantages represented in the attached proposal to initiate a weapons helicopter development programme do not warrant the expenditure involved. Accordingly, the proposal as it now stands is disapproved." These were strong words indeed, but in a quite surprising example of forward-thinking the note continued, "At the same time I want to emphasise that this disapproval is, in essence, a signal to lift the Army's sights in its efforts to provide aircraft for the helicopter escort role. We must now press forward with speed and imagination to develop a more advanced weapons system which will more nearly approximate the optimum [*sic*]. In view of the foregoing, please have the Staff prepare recommendations aimed at reaching this objective."

The Army did indeed lift its sights. It specified that the new AAFSS helicopter should have a top speed of 220 kt (407 km/h; 252 mph) and a ferry range of 2,100 nm (3886 km; 2,415 miles) – enough to fly from California to Hawaii, to cross the Pacific with another refuelling stop at Guam or to cross the United States non-stop. The speed requirement alone was phenomenal. A UH-1 typically cruised at about 110 kt (125 mph; 201 km/h) and even the UH-1H had a maximum speed of just 126 kt (233 km/h; 145 mph). The primary task of the AAFSS would be to escort the CH-47A Chinook (which entered service in 1962) during airmobile operations, but also to provide suppressive fire at landing zones. The AAFSS's high speed would allow it to range ahead of the troopships, providing forward and flanking security against enemy forces, particularly AAA positions. The notion that the AAFSS would then 'stick around' to provide dedicated CAS for those troops (or be called up to do so) would become a hugely contentious issue between the Army and the Air Force. Tentative armament specifications included a 40-mm grenade launcher, a 30-mm cannon, plus six TOW or Shillelagh anti-tank missiles, then under development. In all, the AAFSS's warload would be a hefty 12,000 lb (5443 kg). An advanced fire-control system would be fitted, including, for the first time on an operational helicopter, some kind of night targeting/acquisition system, and the AAFSS would have to be capable of all-weather operations. Though it is commonplace today to brandish phrases like 'integrated weapons system' and 'sensor platform', the AAFSS was conceived as the very first helicopter (if not combat aircraft) that could operate autonomously at night, finding and attacking its own targets, with a reliable and accurate navigation and communications system that allowed it to work in concert with friendly forces on the ground or in the air. While such capabilities are taken for granted by equivalent modern aircraft, like the AH-64 Apache, for the AAFSS it was a revolution..

Urgent need

A total of 12 US companies submitted technical proposals by the deadline of 23 November 1964. Cost proposals followed by 1 September 1965 and the formal contract award was scheduled for 1 November. The war in Vietnam ensured that the AAFSS timetable would be a rapid one. As it proceeded, the Army made a seemingly small, but important, decision, when it ordered the go-ahead of the Bell AH-1G HueyCobra. The AH-1 was intended to be a stopgap aircraft only, drawing on Bell's experience with the UH-1 to quickly develop a light-

Seen here between the 30-mm cannon and 7.62-mm Minigun of the sixth Cheyenne (66-8831), Donald Segner was the Project Test Pilot and later the Chief Test Pilot for the AH-56. In addition to undertaking much of the test flying, Don Segner designed the crew stations and a number of other parts of the aircraft.

Above and above right: The rollout of the first YAH-56 on 16 April 1967 was attended by many high-ranking representatives of the Army and Lockheed-California. The aircraft was officially named 'Cheyenne', in line with Army practice.

Right: After the formalities were over, there was a chance to inspect the new machine. This view shows the crew entry method – up the retractable steps and along the sponson to the cockpit.

weight gunship that could fill an urgent need before the AAFSS arrived. The decision to go ahead with the AH-1 was also linked to the ingrained relationship between Bell and some of Army Aviation's most influential decision makers. As the AAFSS competitors drew up their proposals, two companies emerged as front-runners – with remarkably similar designs. Both Sikorsky Aircraft and Lockheed (then the Lockheed-California Company) conceived a heavyweight, two-crew tandem-seat helicopter, incorporating a compound rotor system. Sikorsky's aircraft was dubbed the S-66, while Lockheed's was the Model CL-840 (later Model 187).

For a company with little or no mainstream practical helicopter production experience, the CL-840 was a brave step forward by Lockheed. Though it had undertaken limited helicopter research for several years, this would be the company's first large-scale rotary-wing project. As AAFSS design and development progressed, headed up by company Vice President Jack G. Real, Lockheed was working on a myriad of other projects, from the C-5 Galaxy to preliminary SST designs. It was the largest defence contractor in the United States, and with the technology it developed for the AAFSS it hoped to achieve a breakthrough in the civilian helicopter market, too. The first drawings of the AAFSS revealed a large four-bladed helicopter sitting on a stalky mid-set main gear. This standard gear allowed the AAFSS to be taxied like a conventional aircraft, using just the tail rotor and the pusher prop, but also gave the underfuselage gun turret the maximum field of fire while sitting on the ground. The undercarriage retracted aft into sponsons, which also housed fuel and an APU (to port). The sponsons would serve as work platforms for maintenance crews, walkways to the cockpits and accommodation for two valuable fuel tanks. The additional volume the sponsons provided reduced the overall profile of the fuselage and increased crashworthiness by keeping fuel in a secondary structure. Power was provided by a 3,435-shp (2563-kW) General Electric T64-GE-16 turboshaft.

Above left and left: The Cheyenne's first flight was scheduled for 11.00 on 21 September 1967, but was delayed for various reasons until after 5.00 that afternoon. Finally, Don Segner took the revolutionary new rotorcraft aloft for a successful 26-minute flight, with no significant complaints logged.

Unconventional empennage

The tail appeared to have been turned upside down, as it had a large fin-like fairing underneath the rear of the upswept boom, on the bottom of which sat a small tailwheel. Two large, slightly swept-back wings were fitted to the streamlined sponsons on the fuselage sides. The end of the tailboom was fitted with a pusher propeller, in addition to a conventional tail-rotor fitted to the end of the tailplane, on the port side. This compound helicopter design, which used the propeller for thrust and auxiliary wings to unload the main rotor at high speeds, allowed the CL-840 to outperform any other existing conventional helicopter.

Furthermore, the design incorporated a rigid rotor, a concept which Lockheed had surprisingly resurrected from the earliest days of the helicopter. Early rigid rotors promised speed and stability coupled with instant manoeuvrability, uncomplicated construction and light weight, but they had historically proved to be unreliable and inherently prone to failure. Also, the gyroscopic effect of these early rigid rotors tended to control the helicopter, rather than the other way around. Lockheed developed a whole new approach, innovatively taking advantage of the same gyroscopic properties of a

Cheyenne 1002 (66-8827) is seen on an early test flight. Unlike those that followed, this first flying aircraft had no fire control system or provision for weapons.

The first flying Cheyennes were 'cleaner' than the later airframes, which were equipped with the periscopic sighting system and the belly turret. The revolutionary features of the AH-56 – the lifting wing and the rigid rotor – are not immediately obvious to the casual observer.

With the prospect of a bright future for Lockheed helicopters, the Rotorcraft Test Facility was built at the Rye Canyon Research Center a few miles north of Van Nuys. Here the AH-56's rotor was tested out of ground effect on a 110-ft (33.5-m) tower, and the Ground Test Vehicle, shown above, was operated for many hours in an artificial 'hover' on this rig.

rigid rotor system – one which, they claimed, would allow undreamed-of speeds to be reached. Promised performance figures for the CL-840 were only slightly less impressive. Acceleration from zero to 200 kt (369 km/h; 230 mph) in level flight was posted at 38 seconds, and 200 kt to full stop at just 17 seconds. Out of ground effect, the hover ceiling was set at 10,600 ft (3231 m) in ISA conditions, or 5,000 ft (1524 m) at 90°F (32°C). At 180 kt (333 km/h; 207 mph) the AH-56 would have a turn radius of 1,450 ft (442 m) or 1,120 ft (341 m) at 140 kt (259 km/h; 161 mph). At low speed, down to 60 kt (111 km/h; 69 mph), the AH-56 could turn over a target in just 200 ft (61 m), in 12 seconds. Lockheed promised the Army its desired maximum speed of 220 kt (407 km/h; 252 mph) at sea level and a service ceiling of 26,000 ft (7925 m). Maximum rate of climb would be 3,420 ft/min (1042 m/min). Operational range would be 760 nm (1403 km; 872 miles) and ferry range would be 2,500 nm (4619 km; 2,870 miles).

Similar Sikorsky

Sikorsky's rival design, the S-66, was a 'semi-compound' helicopter – and based largely on the existing HSS-2 (SH-3 Sea King). Its wings unloaded the rotor at high forward speeds, but primary propulsive power was exercised through the main rotor. Like the CL-480 it was fitted with a pusher propeller, but one which rotated through 90° to act as a conventional (anti-torque) tailrotor at low speed. Sikorsky called this the Rotoprop. It would change mode automatically through the 60-100 kt speed range, but also have a manual override. The main rotor was a conventional articulated system, with four blades. The S-66 had a two-man crew, in separate cockpits (unlike the CL-840) with about 5 ft (1.52 m) between them. Sikorsky opted for the 3,400-hp (2536-kW) Lycoming T55 turboshaft which, in the final design configuration, was situated aft of the rotormast to improve centre of gravity limitations and simplify transmission to the Rotoprop. The S-66 was generally similar in appearance to the CL-840, with a nose-mounted turret and underwing hardpoints. The only other significant airframe difference was the inclusion of a T-tail above the boom.

On 9 March 1965 both companies were awarded a six-month development study

Today we are used to seeing weapons loadout photographs for attack helicopters, but in 1968 it was something new to see a rotorcraft with such an extensive and varied arsenal laid out before it. Shown here are (top to bottom) fuel tanks (seldom if ever carried on a Cheyenne), 30-mm cannon shells, 40-mm grenades, TOW missiles (launchers on the inner pylons) and 2.75-in rockets (outer pylons).

YAH-56A Cheyenne 66-8827 1967

Control surfaces
The Cheyenne had a horizontal and vertical tail, but these were smaller than might have been expected owing to the contribution made by the pusher prop in pitch and yaw control – combined with the tail rotor's obvious yaw input. The wings were set at an incidence that allowed them to lift the Cheyenne's full gross weight, at V_{max}, with a level fuselage. Though they had no control surfaces, the outboard trailing edges did have a preset tab droop to counteract prop torque at high speed. This fixed deflection was set down to starboard and up to port.

Transmission
The Cheyenne's main transmission contained all the gear reduction required for the main rotor and pusher propeller. The prop drive shaft operated at prop rpm, eliminating the need for further gear reduction. The prop shaft was over 6 in (15 cm) in width to make it resistant to damage from ground fire.

Weapons
Unlike those that would follow it, this aircraft was not fitted with armament, although the housing for the XM51 nose turret was in place. This was designed to carry an XM134 7.62-mm Minigun or the XM129 40-mm grenade launcher, although the former was not a success. Later Cheyennes also carried the belly-mounted XM52 30-mm cannon and the periscopic sighting system which considerably altered the aircraft's profile. Theoretical maximum load for a combat-equipped Cheyenne was two three-round TOW launchers and four 38-shot rocket pods, with a total of 152 2.75-in rockets.

Air filtration
As a result of sand and dust ingestion problems encountered in Vietnam, Lockheed developed an air filtration system in conjunction with the Donaldson Company. During operations in sandy conditions, a butterfly valve would shut off the main engine intakes and open a perforated sidewall on the fuselage sides to draw in air. The cylindrical filters were mounted inside the perforated sidewall and trapped 80 per cent of particles larger than 20 microns.

66-8827 c/n 187-1002 was the first Cheyenne to fly, on 21 September 1967. It was used for basic aerodynamic handling and validation of the flight control system as part of Lockheed's portion of the test programme. This aircraft was not updated with a weapons system, the upturned exhaust or other features of the AH-56s evaluated by the Army, and was stored for some time. After the final termination of the programme, the aircraft, which was paid for by the Army and was theirs for disposal, was put on display at the Fort Polk Military Museum in Louisiana.

Mike Badrocke

Above, right and below: The Cheyenne was first flown before the media on a windy day at Van Nuys in December 1967. The third aircraft, which, like the fourth, wore white-edged 'Army' titles, was put through its paces including hovering turns, transition to wingborne flight and a pass at 170 kt (315 km/h). The display culminated on the taxiway with a 'Cheyenne bob' where the nose was dipped in a bow to the audience.

Famed Lockheed test pilot Herman 'Fish' Salmon boards the third Cheyenne using the inbuilt step, emphasising the rotorcraft's great size. As well as Salmon, another Lockheed legend, Tony LeVier, made a few flights during the test programme.

The Cheyenne was huge for a two-crew helicopter. The pilot's eyeline was 9 ft (2.74 m) above the ground. At 54 ft 8 in (16.70 m), it was 5 in (12.7 cm) longer than an F-8 Crusader with a wingspan 5 ft (1.52 m) greater than Lockheed's own F-104. The rotor was just over 50 ft (15.24 m) in diameter. Each of the tail rotors was 10 ft (3.1 m) across.

contract by the US Army Aviation Material Laboratories (AVLABS), at Fort Eustis, Virginia. On 1 September Lockheed and Sikorsky submitted their Contract Definition Proposals and just two months later, on 3 November, the Lockheed design emerged as the sudden winner. The decision in favour of Lockheed was indeed a rapid one and was made only a few hours before it was announced. The Army was seeking an initial production run of 200 aircraft at an estimated unit cost of $500,000. The stability afforded by Lockheed's rigid rotor concept was cited as one of the main decisions in favour of its design, as it would thus be a better gun platform. The AAFSS, under Project Manager Lieutenant Colonel Emil E. ('Jack') Kluever, became the first major Army weapons system to be developed under the new Department of Defense development cycle (Directive 3200.9) introduced by Secretary of Defense Robert S. McNamara. This process involved a phased programme of definition (Phase 1), engineering development (Phase 2) and production (Phase 3) contracts – a system that is so familiar today. The engineering contract for 10 prototypes (to facilitate a rapid test programme) was not formally signed until 23 March 1966, but had been anticipated since the day CL-840's victory was announced. The official designation AH-56 was allocated along with the contract and the prototypes would become AH-56A-LOs (66-8826 to 66-8835). They would comprise one non-flying ground test vehicle (GTV), one flying model with no weapons or fire control system and eight 'pre-production' aircraft, built to a (near) operational standard. The original in-service target date was 1972, but both Lockheed and the Army believed that this could be brought forward to 1970 – or even earlier.

Two Cheyennes cruise near the California coast on a company test flight. It was off the town of Carpinteria on 12 March 1968 that Lockheed pilot Dave Beil's aircraft entered an oscillation and subsequently crashed. The accident had far-reaching consequences for the programme.

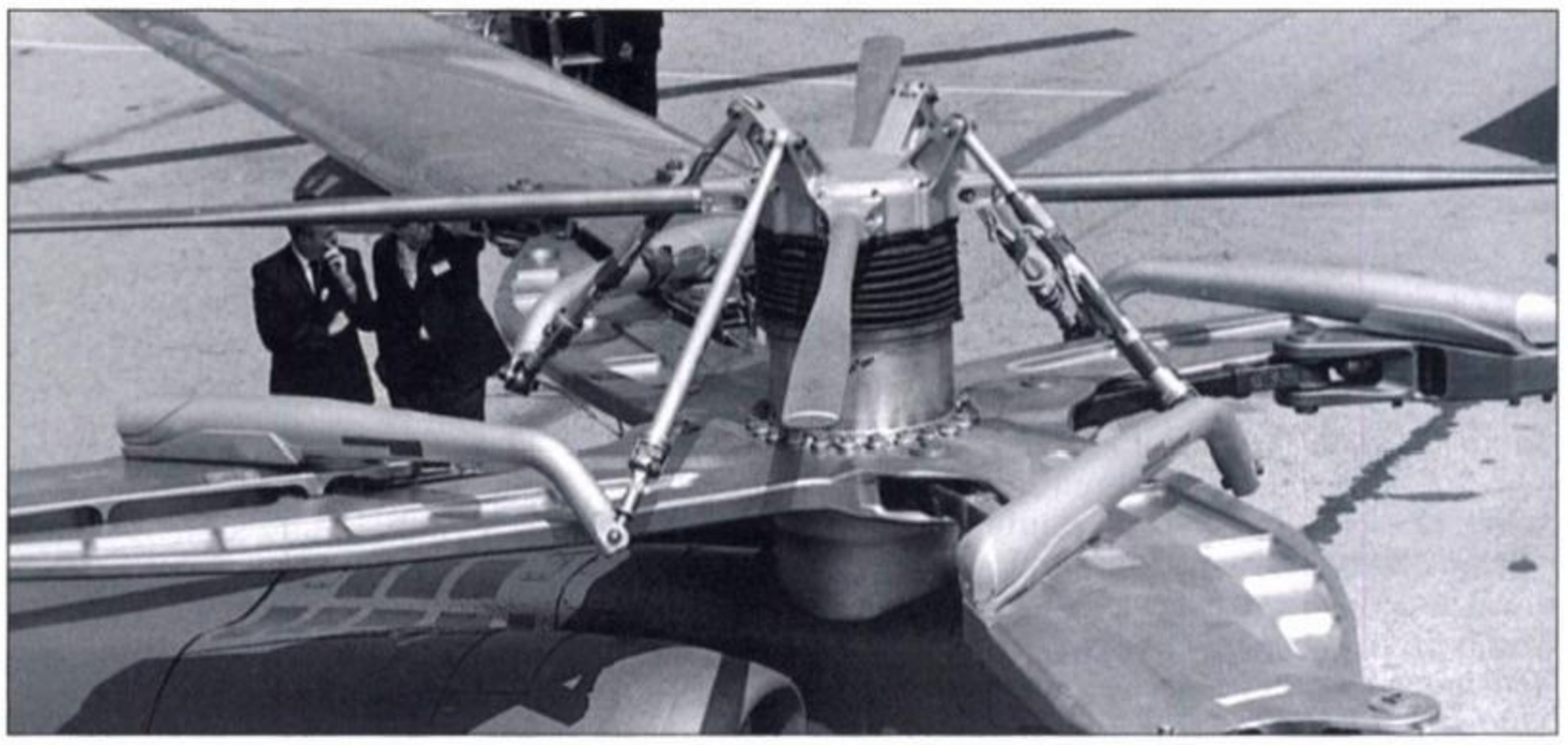
By 7 June 1966 the mock-up review was complete. Lockheed promised strict maintainability guarantees, keeping the AH-56 in line with standards that had been set by the (much less complex) Hughes OH-6. Maximum maintenance man-hours per flying hour was set at 3.9 in the field, and 1.9 at higher level. Engine removal was set at just 30 minutes. Time between inspection was set at 300 hours and between major maintenance at 1,200 hours. Operational availability was set for 85 per cent, with a nine-minute servicing time, 10-minute re-arming time and 10-minute armament reconfiguration time.

Home of the AH-56A was Building 901 at Plant 8 of Lockheed's Van Nuys factory, in California. The first aircraft, the non-flying YAH-56A GTV (1001, 66-8826), was rolled

Cheyenne in detail

This head-on view illustrates the GE Minigun originally planned to be interchangeable with the grenade launcher, but which was, in the end, only fitted to the no. 4 aircraft. The periscope is seen rotated to the rear.

Below: The crew seats were conventional, if unarmoured, helicopter seats. In one aircraft, however, a Lockheed F-104-type downward-firing ejection seat was fitted. This was probably the first helicopter fitted with a 'bang' seat, albeit one impractical at low altitude.



Below: A close-up shows the main gear and its well. The Cheyenne was one of the first helicopters to have a retractable wheeled undercarriage, later adopted by the Mil Mi-24.

Above: The Cheyenne's rotor system used significant amounts of titanium and was immensely strong. At the top of the mast was the four-armed control gyro, which controlled blade pitch through linking arms to the prominent blade feathering arms.

Below: The semi-retractable tailwheel was mounted at the base of the ventral tailfin.

out on 16 April 1967 in front of the chief of US Army research and development Lieutenant General Austin Betts (the roll-out date has often been reported as 3 May). The new aircraft was named Cheyenne at the ceremony, in keeping with the US Army tradition of adopting American Indian names, rather than with Lockheed's preferred celestial theme.

Lieutenant General Betts described the AH-56 as a long-sought 'big jump' and went on record as saying that the Army would probably need between 500 and 1,000 Cheyennes – and that such a total could easily rise. Lockheed prepared two procurement planning and pricing structures, one calling for accelerated deliveries through mid-1971 and a slower-paced schedule to be completed by 1972. Four production quantities – 375, 500, 1,000 and 1,500 – were priced for each proposal. A sign of things to come was the creep upwards of the price of a Cheyenne. The 'fly-away' price was by then quoted as approximately $1,000,000 including engine, avionics and weapons (but not spares). Even then, many of those involved with the programme did not believe that the avionics development would be straightforward, and felt the price would climb by at least another $500,000 once all the work was done and the bills were in.

Certifying Cheyenne

AH-56 testing was scheduled to start in the hands of the Federal Aviation Administration (FAA) by July 1968, with FAA certification planned for October. This unusual civil certification process was essential if Lockheed was to gain commercial acceptance of the rigid rotor system – and the company already had the 30-seat Model 1026 civil transport helicopter on the drawing board along with a military transport equivalent. US Army service evaluation of the Cheyenne would begin in March 1969. The total civil/military test programme was estimated at 1,000 hours.

As the Cheyenne progressed towards its September 1967 first flight, essential development work was underway at Lockheed's nearby Rye Canyon Research Center to perfect the new rigid rotor system. A full-scale 'whirl tower', capable of lift, pitch and roll motions, was built to test the large four-bladed rotor. The first ground tests of a rotor on an actual airframe took place in May, involving two aircraft, which conducted tie-down, endurance and dynamic response testing.

The AH-56's rotor system was built around a massive electron-beam welded titanium hub that had to be immensely strong to cope with the loads imposed by its rigid rotor system. Much of the titanium metalworking technology used in the AH-56 was derived from Lockheed's pioneering experience with the A-12 programme. The rotor blades were attached to 3-ft (0.91-m) titanium extensions from the hub and could rotate through 28°: 18° of collective pitch, 8° cyclic pitch and 2° negative pitch for idling. However, they were not free to flap or 'hunt' as in a teetering (semi-articulated) or articulated rotor. The shape of the blades was optimised to control feed-back into the gyro and for (very) high-speed flight.

The main rotor operated at a maximum rate of 246 rpm, which equated to a tip speed of 650 ft/per second (198 m/s). In contrast, the tailrotor had the same tip speed but operated at 1,238 rpm. The pusher propeller turned at 1,717 rpm, with a tip sped of 900 ft/s (274 m/s). The main rotor blades had a constant 28-in (71-cm) chord and were of bonded 'composite' construction (without using non-metallic 'composites' as we understand the term today). A Z-shaped titanium spar and leading

Above and below: The Cheyenne was one of the fastest rotorcraft ever built. The Army's own requirement called for a maximum speed of 220 knots (407 km/h), which is faster than the current world record of 216.45 kts (401 km/h), held by a Westland Super Lynx. The third Cheyenne achieved 226 kts (418.5 km/h) before its loss, and the much heavier ninth aircraft was edging towards the requirement by the end of the Army's test programme.

The Emerson gun and grenade-launcher system theoretically allowed simultaneous engagement of targets on either side of the Cheyenne. The photo above shows the pilot – wearing a helmet-mounted sight – and the gunner, his periscopic sight and the gun turret all swivelling simultaneously. At left, the XM51 belly turret is shown in close up.

edge was wrapped with a titanium/stainless steel skin filled with a weight-saving aluminium honeycomb core, all using epoxy bonding. The total rotor diameter was 50 ft 4.8 in (15.39 m).

Even before the AH-56 made its first flight, speculation had started that the Cheyenne would supplant the USAF's A-1s (and B-26Ks) in the CAS role. The firepower, superior speed and survivability of the Cheyenne made it the perfect candidate to replace the elderly Skyraider. Army officials played down any such role, but unofficially it was noticed that the Cheyenne was easily capable of strafing or rocket runs with all the accuracy of the A-1. Don Segner, the project test pilot and later Chief Test Pilot, came up with a 60° dive-bombing technique for the Cheyenne using the tail prop as a speed brake. The AH-56 began to pique interest among the other services. The Navy identified a requirement for between 70 and 100 aircraft for 'Riverine' operations, and perhaps even for SAR duties with a winch fitted. The Marines, too, were interested, but as was often the case simply had no money available. Some in the USAF even speculated that a number of additional prototypes might be built for evaluation with an eye on 'special warfare' Air Commando operations. The Air Force's emerging A-X close-support aircraft requirement was also influenced by the AH-56, though the USAF remained outwardly committed to a turboprop aircraft (at least during the early years of the A-X definition).

On 21 September 1967 the Cheyenne (1002) made its maiden flight (which has also been widely but incorrectly recorded as 10 October) with Lockheed test pilot Donald R. Segner at the controls. The Army's Lieutenant Colonel Kluever flew in the front cockpit (which had no flight controls or instruments) as an observer – a role he insisted on taking before he would approve the flight. During the 26-minute flight Don Segner completed the entire test card and 'felt out' the aircraft. He experienced strong cross coupling (the aircraft's flight axis had shifted to the right and so to remain nose down the stick had to be pushed forward and across by 20° or 30°) but this was a common phenomenon in initial helicopter test flying and was cured by the time Cheyenne envelope expansion flying began at Van Nuys and Oxnard.

Performance for the press

On 12 December the AH-56 made its public debut with an impressive and well-received 13-minute flight demonstration at Van Nuys, again flown by Segner in the No. 3 prototype. Contemporary press reports recorded that "the compound helicopter banked and zoomed upwards sounding much like a World War II fighter". Despite being at a very early stage in its development (having flown only 15 hours), the Cheyenne was operating at a speed 'limit' of 170 kt (314 km/h; 195 mph) and a bank angle limit of 30°. In a crosswind of 30-40 kt Segner held the Cheyenne in a steady hover and moved the aircraft forward and back using only the tail propeller. The display ended with a manoeuvre that became known as the 'Cheyenne bob' – a touch-down with the main gear on the runway but holding the tailwheel about 5 ft (1.52 m) in the air while taxiing in.

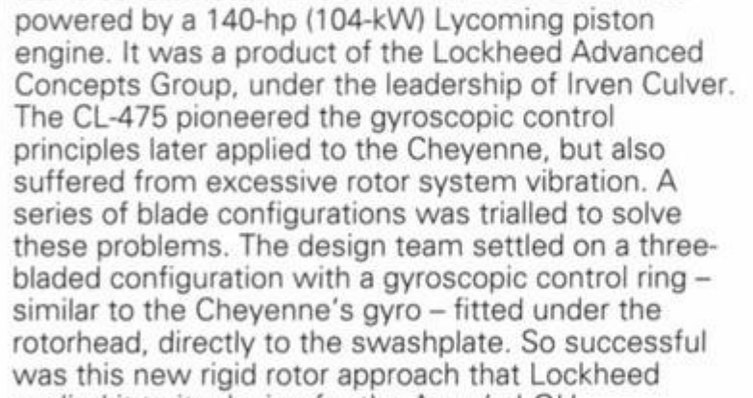
Behind the happy scenes at Van Nuys, troubles had arisen over paying for the Cheyenne. The fighting in Vietnam was driving the requirement for the AH-56, but the cost of the war was also cutting back the money available for such development contracts. The Army desperately tried to have additional production funds allocated to the AH-56 in the next fiscal year (FY68) that would allow it to sign the production agreement with Lockheed. Requests for extra money were turned down by Robert McNamara – it would not be available until FY69 – so attempts were made to take money from other projects and re-allocate it to the Cheyenne. The problem facing the Army was that its outline contract with Lockheed would expire on 31 December 1967 and afterwards it would be forced to renegotiate the price, which would increase. The price would also increase if the Army selected the lowest Lockheed production option, 375 Cheyennes. Lockheed was promising delivery of the first production Cheyenne 21 months after contract approval, with first deliveries in September 1969. Production rates were anticipated at approximately one-and-a-half aircraft per day.

On 8 January 1968 the Army's scramble for funds paid off when $21.4 million was allocated for "pre-production planning, engineering and procurement of long lead-time material". Lockheed had extended its December deadline. The money was found in what the Army would come to call an 'equal cost trade-off', in which other helicopters, artillery and support units were sacrificed in the hope that the Cheyennes would provide more combat power per dollar.

Lockheed's pioneers – the CL-475 and XH-51A

Lockheed's first rigid rotor test flights were conducted by the CL-475 helicopter that first flew on 2 November 1959. The small CL-475 had a simple fabric-covered steel and aluminium frame and was powered by a 140-hp (104-kW) Lycoming piston engine. It was a product of the Lockheed Advanced Concepts Group, under the leadership of Irven Culver. The CL-475 pioneered the gyroscopic control principles later applied to the Cheyenne, but also suffered from excessive rotor system vibration. A series of blade configurations was trialled to solve these problems. The design team settled on a three-bladed configuration with a gyroscopic control ring – similar to the Cheyenne's gyro – fitted under the rotorhead, directly to the swashplate. So successful was this new rigid rotor approach that Lockheed applied it to its design for the Army's LOH competition that gave birth to the Hughes OH-6.

Success with the CL-475 was followed by the more advanced, streamlined four-seat CL-595 design. For high-speed trials the CL-575 had a much more sophisticated rigid-rotor design and impressed the US Army and Navy with its predicted performance. Two examples were built as XH-51As (Model 186) for the Navy, BuNos 151262 and 151263. The first flew on 2 November 1962, powered by a 550-hp (410-kW) PT6B-9 turboshaft. After the initial three-bladed rotor was replaced by a four-bladed one, the XH-51 proved to be an excellent performer, demonstrating a top speed of 174 mph (280 km/h).



The otherwise unsophisticated CL-475 pioneered the rigid rotor helicopter concept. Here it is fitted with the gyroscopic ring and metal rotor that cured vibration problems.

The Army's project manager for the AH-56 programme, Lt Col Emil Kluever, poses with* Little Chief, *the record-breaking Lockheed XH-51A.

In 1964, under an Army contract, Lockheed 'compounded' one of the two XH-51As by adding lifting surfaces and a 2,900-lb (12.9-kN) Pratt & Whitney J60-P-2 jet engine. The jet engine gave the rigid-rotor XH-51A a source of thrust, independent of the PT6 that drove the main rotor. In forward flight the J60 unloaded the main rotor, reducing the critical blade tip speed and blade angle, allowing the helicopter to fly much faster. Flight tests began in May 1965 and the XH-51A soon began rewriting the record books. It reached a top speed of 302.6 mph (486.9 km/h) in level flight and accelerated from a hover to 230 mph (370 km/h) in 45 seconds. It could hover turn through 360° in just five seconds, had a bank angle of 120° and a usable roll rate of 50° per second. The XH-51A pushed back the boundaries of helicopter flight beyond their previous theoretical limits and remained controllable throughout. Even at 220 mph (354 km/h), the rotor system could handle a load of 3*g*. The compound XH-51A flew widely on demonstrations throughout the USA and Europe and was even in the running for an order from the Netherlands navy for ASW tasks. The CL-475 and both XH-51As now reside in the collection of the US Army Aviation Museum at Fort Rucker, Alabama.

Application of pitch change on the pusher propeller allowed the AH-56 to hover with nose up as much as 17° or down as much as 10°, allowing more flexibility in weapons firing over rough terrain. Here a Cheyenne demonstrates 'lofting' rockets in the hover.

Assembly of the first production Cheyenne would begin on 20 September 1968, with first delivery following in October 1969. The Army still had to find money for avionics and engine development and had also been forced to sign for just 375 aircraft. Although the eventual requirement was still optimistically put at 'over 600', funds were tight and no-one could predict what would actually be available in FY69, or beyond. Furthermore, the 375-aircraft option pushed the unit price up to its highest level and the Army disputed Lockheed's cost calculations which quoted only four permissible totals (375, 500, 1,000 and 1,500), which meant that 600 aircraft would seemingly cost the same as 500.

Capable of carrying 12,000 lb (5443 kg) of ordnance, nearly as much as a B-17, the AH-56 was often called a 'flying tank', but the designers never envisaged a warload quite like this one of bombs and Bullpups. When it was discovered that the pusher prop could be used as a speed brake, making dive-bombing attacks feasible, this loadout was arranged to impress a potential customer, supposedly the Air Force.

The main anti-armour weapon proposed for the AH-56 was the BGM-71 TOW missile. Not available when the AAFSS concept was defined (production only began in late 1968), TOW transformed the Cheyenne from an armed scout into a tank killer. A unique three-shot launcher (above left) was devised and the first firings took place at Yuma in 1968 (above).

The Army felt that more aircraft should cost individually less.

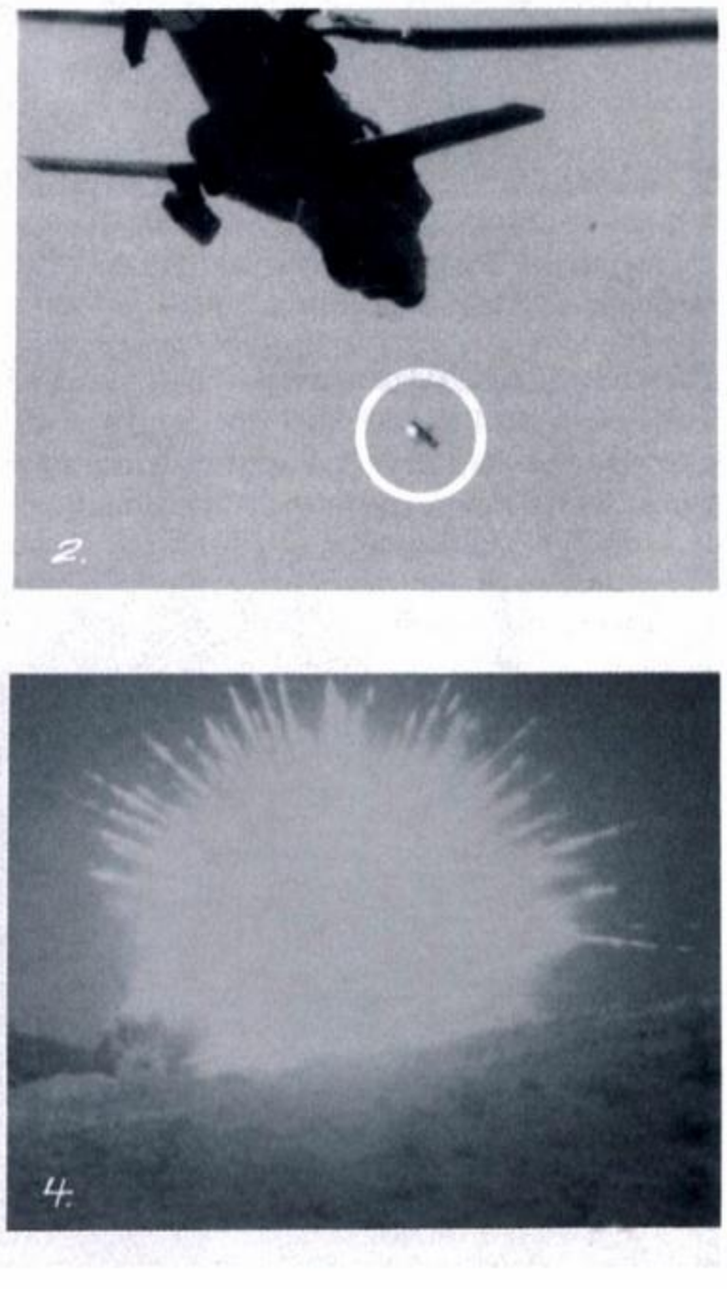
Throughout it all, one point remained important but unspoken. The Congressional approval for 375 Cheyennes meant that the Army had won the first round of its battle with the Air Force to expand its future combat air power. Behind the scenes, questions had been raised in Washington, by 'concerned parties', as to just why the Army needed all these fancy new helicopters, but those dissenting voices had been ignored – at least for the time being.

Lockheed began planning to undertake all Cheyenne fabrication work at Burbank, all sub-assembly work at Van Nuys and final assembly and flight test at Palmdale. By the time the January funding decision was announced, approximately 20 flight hours had been chalked up by three prototypes (Nos 2, 3 and 4). The No. 5 aircraft joined the programme later that month as an avionics testbed. The No. 4 aircraft was then detached to Lockheed's Potrero range

The AH-56 could carry rockets or TOW in a variety of combinations, the maximum load dependent on density, altitude and required range. A theoretical maximum of 152 2.75-in (7-cm) rockets, contained in four 38-round launchers, could be carried.

Above: The turret of a surplus M4 Sherman shows the effect of a burst of 30-mm fire from the AH-56's cannon.

Below: Another M4 meets its fate at the hands of a TOW (Tube-Launched, Optically-tracked, Wire-Guided) missile. The first firings from the Cheyenne were made from the hover with gear down, but soon multiple kills were being scored from forward flight.



The sixth AH-56 (66-8831) was used for weapons trials at the Yuma Proving Range in Arizona (today the Barry M. Goldwater Range). The pod seen on the inner pylons is in fact a modified TOW launcher with frangible end caps.

facility, near Redlands, California, for weapons trials which also began in January. On 24 January the No. 6 aircraft joined the test fleet, with No. 7 following in February. By March 1968, 58.9 hours had been logged over 144 flights, performed chiefly by just two aircraft. Prototype 1002 (the first flight vehicle) was dedicated to establishing the flight envelope, conducting rotor/prop stress surveys, defining autorotation characteristics and general vehicle system development. 1003 was fully instrumented to measure load data, powerplant performance and handling qualities. 1004 handled initial weapons tests. 1005 was dedicated to avionics development. The remaining aircraft were charged with air firing tests, EMC evaluation, FAA function and reliability testing, maintenance training, performance evaluation by Army pilots (the so-called Phase D testing) and automode test and development. Army environmental testing (Phase E) and service testing (Phase F) would follow by November 1969.

The flight test programme proceeded in a step-by-step fashion testing vital incremental changes of the collective and propeller blade settings. By March 1968 the Cheyenne had demonstrated a forward flight speed of 170 kt (195 mph; 314 km/h), sideways flight at 25 kt (27.5 mph; 44 km/h), rearward flight at 20 kt (23 mph; 37 km/h) and load factor of 1.6 *g*. Special attention was, of course, paid to the unique propeller and tailrotor configuration, considered by many to be a potential risk. To overcome resonance problems encountered on the GTV, the pusher prop gear box received 'harder' mounts and the tip weights were increased to modify the blade frequency. Vibration problems also surfaced with the cockpit canopies which were stiffened and fitted with a new latch mechanism.

Armoured enthusiasm

It is still hard to overstate the impact that the Cheyenne would have had on US Army operations, had all gone well with the aircraft. The November/December edition of the Army's *Armour* magazine – devoted to the tank crews who were the spearhead of the modern Army –

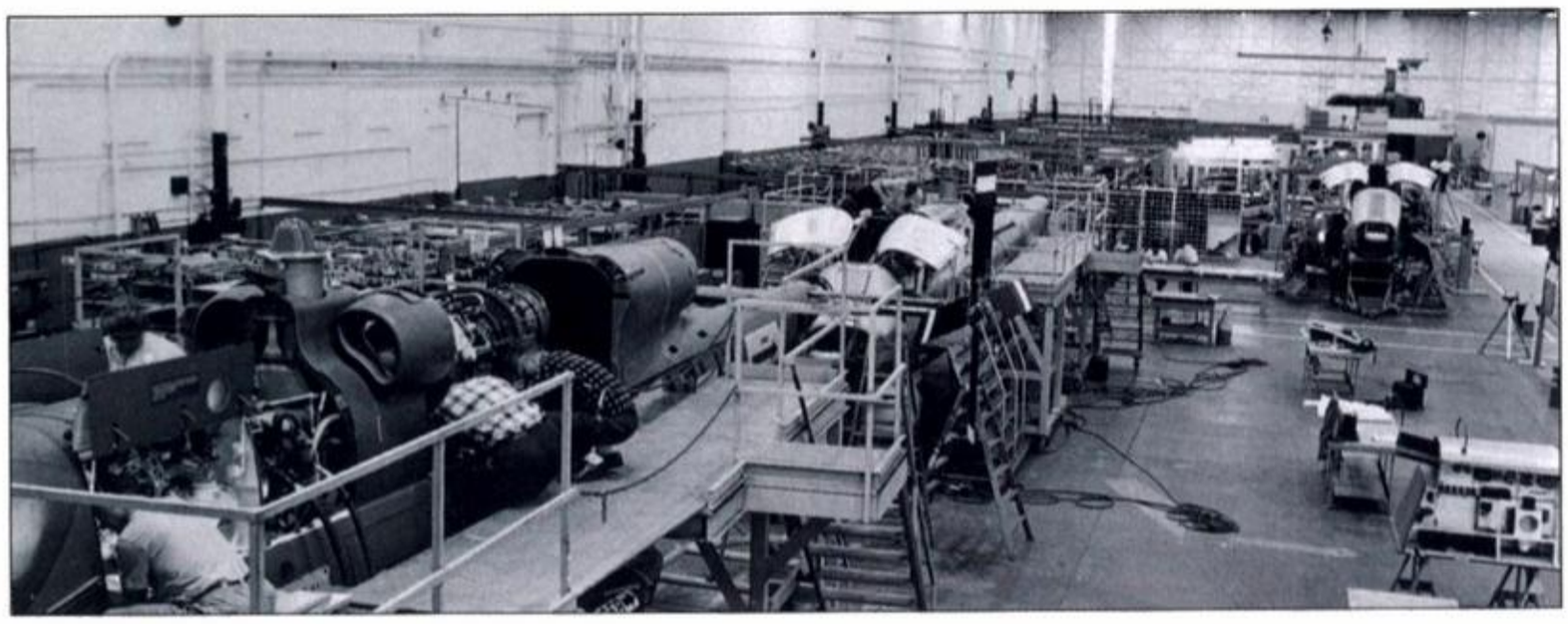
was unfettered in its enthusiasm for what the Cheyenne would bring to the battlefield, and with good reason. In a mock Q&A session conducted between the reader, playing the part of a 'typical' hard-bitten tank battalion commander, and a Cheyenne platoon commander, *Armour* recounted how "this morning when the enthusiastic Cheyenne unit commander reported to you and started telling you all these wondrous capabilities of the AH-56, your old Missouri blood began to boil. So you interrupted the Cheyenne commander and told him in no uncertain terms that sales pitches by zealots might be tolerated under peacetime conditions in the States, but dammit, we're at war, and we have a fight on our hands, right here, today! So cut the chatter on what your bird might do under optimum conditions and tell me how much ammunition it will carry and how long it will fly under the conditions of today and right here!" For Army units tired of seeing supporting aircraft leave the battle to rearm and refuel, just when they were needed the most, the Cheyenne seemed to have all the answers.

The AH-56 would have a mission endurance of two-and-a-half hours (three hours total flight time) plus reserves, on its full internal fuel load of 2,850 lb (1292 kg). At desert conditions of 2,000 ft (210 m) elevation with temperatures peaking at 80°F (27°C), the Cheyenne commander could guarantee a warload of 2,010 rounds of 30 mm, 780 rounds of 40 mm, six TOWs and 38 2.75-in rockets. In the Mekong Delta, where the temperature could climb to 100°F (38°C), the Cheyenne could haul full fuel, full internal ammunition and 114 rockets. Even in the highlands of Vietnam, where temperatures were at their highest, the Cheyenne could carry full fuel and internal ammunition with 38 rockets.

The article imagined the scene as one Cheyenne 'fire team' kept a lookout for enemy units ahead of friendly armour (performing that most modern of battlefield helicopter tactics, overwatch) while the remainder of the five-ship platoon stood by on alert just behind the lines. Once in the air, the Cheyennes provided flank security for the ground forces, flexible reconnaissance and rapid fire support for troops in trouble. The Cheyenne's magnifying sight allowed it to search for and positively identify targets at long range. It could look behind hills and ridgelines from a safe distance, while accurately plotting targets with a laser rangefinder. The gunner could allocate precise UTM map co-ordinates to that target and relay them to ground forces by common FM radio, either to alert them or call in artillery fire. The Cheyenne, it was planned, would be just as capable at night and proficient at fully self-contained navigation over any terrain with its Doppler/INS system. The Cheyenne's own long-range and highly accurate weapons system had a high first-burst hit capability, with no need to 'hose' the target as before, and could sustain accurate fire even while manoeuvring hard. The true combat value of the Cheyenne lay in its ability to combine all these functions in one sophisticated airframe. The Cheyenne would bring a whole new dimension to US Army tactics and operations; more importantly, it would provide the first notional challenge to the dominance of the tank on the battlefield. Such operations extended far beyond the AH-56's original official remit as an escort for troop-carrying helicopters, and would ultimately prove to be beyond the Cheyenne's grasp, but had the Cheyenne survived all its troubles there is no doubt that it would have been the first to break the mould.

Sighting system

The AAFSS specification called for the ability to fire accurately down one side of the aircraft as it passed at 90° to a target and at full speed. This was a demanding requirement that would drive the AH-56's revolutionary sensor and weapons systems. To find and identify targets, the AH-56 was fitted with a magnifying optical sight under the forward fuselage, in front of the ventral gun turret to avoid blinding the optics with muzzle flashes. This primary sight was viewed by the gunner using a periscope in the forward fuselage. The stabilised sight had three stages of magnification – x1.5, x5.25 and x12 – and also incorporated the laser rangefinder and TOW guidance system. Officials boasted that the high-powered sight would allow the Cheyenne to "fire on an automobile radiator cap from a mile and a half". Sight functions were controlled by a 'T-bar' arrangement of



Building 901 of Plant 8 at Van Nuys was where Cheyenne assembly and functional development took place. The latter involved the design and installation of systems routing on the prototype aircraft as they moved along the assembly line.

Above and right: Despite the construction of 10 AH-56 prototypes, it seems that no more than three were airworthy at any one time. One, in fact never flew at all and two others very little. This formation of three variously marked and configured Cheyennes may have been unique.

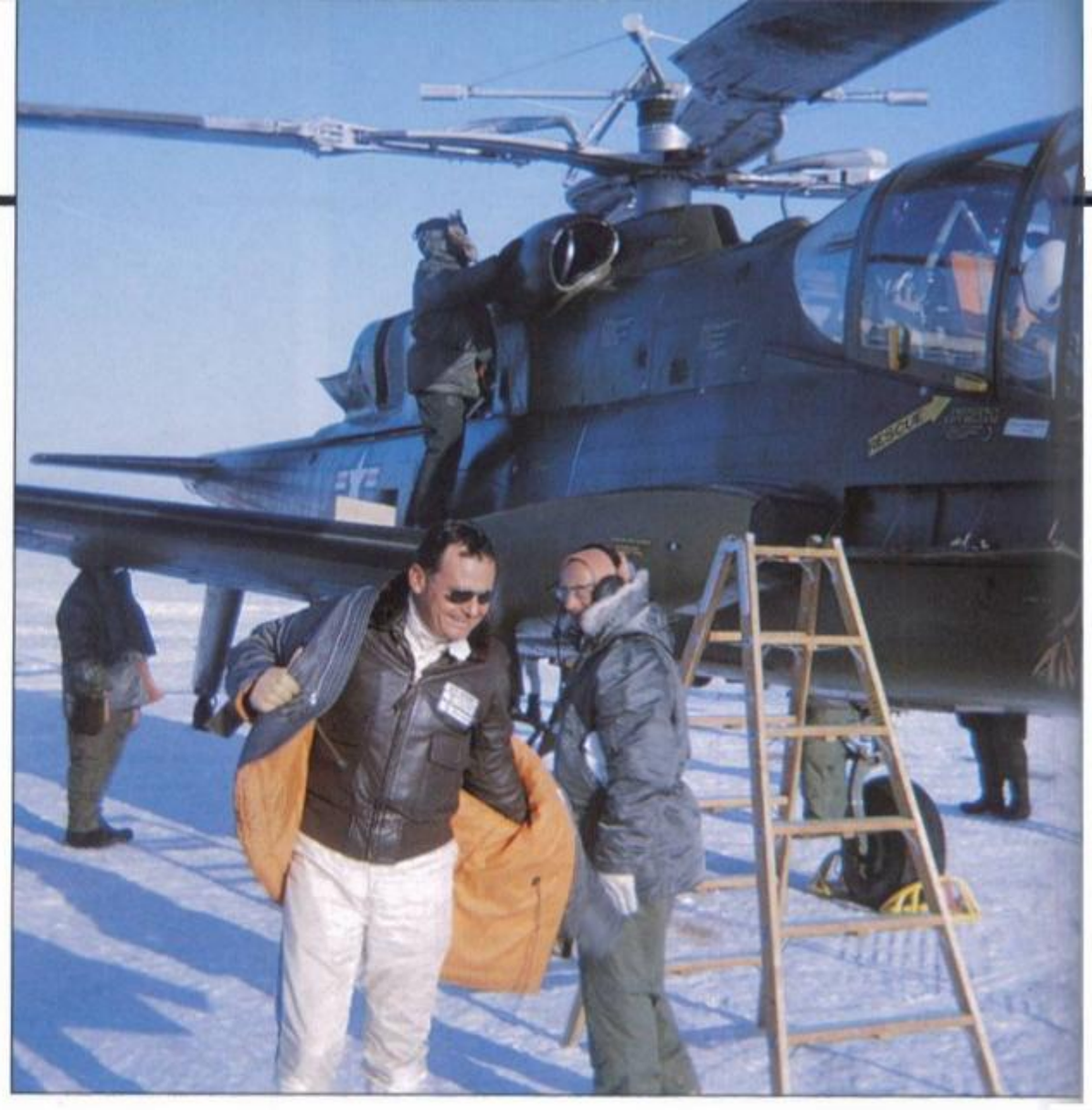
two joysticks, exactly like those found on most modern attack helicopters. Once the gun 'pipper' and aiming reticule was positioned over the target it stayed locked in by the central weapons computer which automatically calculated range, azimuth and angle to target. The cockpits of the Cheyenne, while seeming cluttered today, were models of simplicity for their time and could still rival today's AH-64A cockpits in terms of layout and ease of access. The Cheyenne would have been the first military aircraft with a CRT display for the crew – which proved to be an immense design challenge in simply deciding how to present information. The AH-56's co-pilot/gunner's seat also featured one innovation that had never been seen before, or since. The gunner sat on a stabilised rotating turntable, along with the main binocular periscope sight housing, which could turn through 200° from either side of the aircraft centreline to track a target. As the seat turned, so did the main sight, automatically tracking a target or responding to the gunner's movements to track a target of opportunity. This novel system was developed by General Electric's Avionics Controls Division. The rear cockpit had a centre-mounted cyclic, but the front cockpit had a side-mounted stick, to allow the seat to move freely. The gunner used a stirrup arrangement to control his 'swing'.

Helmet-mounted sight

The pilot had a completely independent weapons sight, a unique new helmet-mounted system: the Honeywell VIPRE (VIsual Precision Fire Control Equipment) Fire-1. The VIPRE sight system was designed to fit over a standard APH-5 helmet and weighed 22 oz (624 g). Nylon screws were used to attach it, so that the impact of a crash would detach the sight from the helmet and hopefully save the pilot from neck injuries. An electrical chord provided power from the main aircraft systems to the sight and helmet motion was tracked by photodetectors. The main body of the sight projected in front of the pilot's head and incorporated a projector with a drop-down combining reticule over the right eye (though it could be set up for use with the left eye also). The eyepiece had a standard gun sight with a crosshair and outer mil rings. Using ballistic information from the weapons computer, the sight determined all correct aim angles, offset points, lead and drop for either of the turreted weapons. Somewhat alarmingly, the pilot could also use the helmet-mounted sight to 'command swivel' his gunner into line with a target he had seen.

The weapons on offer to the crew were a versatile mix. A nose-mounted Emerson Electric XM51 gun turret was free to turn through 200° and mounted a Philco-Ford Aeronutronic's XM140 40-mm grenade launcher. The initial plan to provide an interchangeable turret-mounted XM53 7.62-mm

This AH-56 was damaged during ground-running tests on 21 August 1968, when a blade struck the canopy. The unfortunate incident was blamed on an engineer who let an oscillation develop in the rotor system – a situation that someone with more experience would perhaps have avoided. Despite claims to the contrary, this incident did not reveal any inherent flaws in the AH-56 design.



Above and right: Cold weather trials were conducted at the Canadian National Research Council's Flight Research Facility at Uplands, Ottawa in January-February 1969. The aircraft used was the 9th Cheyenne (66-8834), which wore Indian-head nose art as seen at right.

Minigun for the Cheyenne, that could be fitted or removed in the field, was dropped in favour of just the grenade launcher. The XM51 turret could be rotated through 18° in elevation, 70° depression and 200° in azimuth. Ammunition was housed in the nose. The XM140 had a rate of fire of 350 rpm with 780 rounds available. Effective range would be approximately 500 m (1,640 ft).

A Philco Ford 30-mm cannon in an XM52 rotating turret was fitted under the belly. This weapon was specifically design for use with helicopters and combined effective anti-personnel and anti-armour rounds. The XM52 system had a depression angle of 60°, elevation of 27° (with an automatic cut-off to prevent rounds from striking the fuselage while manoeuvring) and could be rotated through 360°. Ammunition was carried in a drum in the main fuselage. The gun operated at a rate of 400 rounds per minute and had a magazine capacity of 2,010 rounds. Effective maximum range was 3000 m (9,843 ft).

Left: Rotor vibration problems were treated by adding wires connecting the gyro arms, changing their natural frequency.

Bottom right: The pusher propeller provided the bulk of propulsion at speed. When reversed, it was a powerful airbrake.

Compound propulsion and rigid rotors

Conventional helicopter aerodynamics restrict rotary-winged aircraft to an airspeed of approximately 200 kt (230 mph; 370 km/h). To reach this airspeed, the tips of the main rotor blades are themselves approaching supersonic speed and begin to compress the air ahead of them. The air becomes less fluid and ceases to flow efficiently over the blades – in effect, the blades are pushing the air away from them. At the same time the retreating blade is moving so slowly, relative to the surrounding air, that the blade has to operate at a higher angle of attack to provide lift. At a certain point this angle will become the same as the stall angle and the blades will cease to function. This places an effective limit on the performance of most helicopters. To retain the essential hovering and manoeuvrability of a helicopter at speeds in excess of 200 kt, a compound helicopter functions as a conventional aircraft with a low-speed lifting device – the rotor.

The AH-56 was built around a wing and a pusher propeller to relieve the main rotor of the majority of its lift and propulsion functions at high speed. The main rotor thus served to get the aircraft airborne and to manoeuvre at all speeds (without the aid of ailerons or a rudder), but at high speeds the wings and the tailprop did all the work, lowered the lift on the main rotor and helped avoid the compressibility/stall phenomenon altogether. The propeller brings other advantages. It could change the AH-56's pitch at any speed, useful for rapidly returning fire or for strafing. The prop did away with the need to dip the nose when a helicopter was transitioning from the hover to forward flight, a potentially useful aid to nap-of-earth flying. The propeller also functioned as a very effective speed brake.

The downside of a compound system added to a conventional (flexible rotor) helicopter is that the wings and propellers take up valuable space, increase the airframe weight and eat away at the payload. On a rigid rotor helicopter, most of this is negated, and the wings can provide space for weapons pylons.

To impart this control power, Lockheed fitted a rigid rotor to the Cheyenne. Rigid rotors, in which the blades attach directly to the rotor mast, were used in the very first helicopter designs. However, they were far from ideal, as rotating blades are subject to huge variations in velocity distribution (they speed up and slow down as they advance and retreat). The result of this is vibration and poor handling, leading, potentially, to complete mechanical failure. As early as 1920, Juan de la Cierva had hit upon the idea of attaching the blades to the mast with teetering hinges that allowed them to flap (a teetering rotor). Flapping blades produced variations in the angle of attack of the rotor disc and this compensated for the asymmetric velocity distribution. From there was a short step to combine a vertical flapping hinge with a horizontal lead/lag hinge (an articulated rotor) which allowed the blades to move in two-dimensions within the rotor disc, further reducing vibration and structural stress. Virtually ever helicopter designed before the Cheyenne used a version of these systems.

Lockheed decided to reject these approaches to take advantage of the benefits of a rigid rotor: stability (particularly in turbulence), unequalled manoeuvrability, high speed, inherent low vibration and mechanical reliability (due to its lack of moving parts). The rigidity of the rotor attached to the mast, through the rotor head, allowed the Cheyenne to develop control movements akin to a fixed-wing aircraft, i.e. independent of rotor lift. All other rotor systems are dependent on the rotor lift for control. LCC developed the first practical rigid rotor system built around a four-armed control gyro, gimballed above the rotor mast. The pilot's cyclic stick in the cockpit was connected to a double-acting spring cartridge which applied force to a free-moving swash plate, at the base of the rotor mast. The swash plate was connected to the control gyro by four control rods, each with universal joints. The four gyro arms were connected by pitch links to the feathering arm of each rotor blade. The gyro applied control inputs directly to the blades as they rotated, in a collective and cyclic manner, thus avoiding the control input time-lag inherent in other rotor designs.

Control inputs were relayed through the control gyro to the blades using the subtle laws of gyroscopic precession. A gyro responds to an applied force by pitching down in a direction offset 90° to the force. This is known as precession. For example a downward force on the gyro causes it to tilt to the right (if it is rotating anti-clockwise). An upwards force applied to the control gyro from below, by the swashplate, had the same effect. Thus, a forward motion of the control stick was transmitted through the spring cartridge as an upwards force to the left side of the swash plate which pushed the gyro in the same direction. The double-acting spring cartridge was essential to this control mechanism as it absorbed stick motion and applied the desired force on the gyro.

The nose-down precession of the gyro altered the angle between the plane of the control gyro and the plane of the rotor, introducing a cyclic pitch change to the rotor disc. Because the rotor is also a gyroscope the resultant lift was upward on the left side of the Cheyenne's rotor disc. The rotor then precesses nose-down until the plane of the rotor disc is parallel to the control gyro. Cyclic pitch change then ceased and the lift over the rotor disc was equalised, but it then had a forward thrust component. Control response is immediate.

Above: Brigadier General Maddox, Director of Army Aviation (at top of ladder), was one of the many high-ranking officers to fly in the Cheyenne. Others to fly or fly in the aircraft included NASA pilots and astronauts, and the assistant Secretary of Defense.

Left: The Lockheed test team takes a moment to celebrate the beginning of Army Preliminary Evaluation (APE) Tests at Edwards AFB in January 1969.

Both the grenade launcher and the cannon suffered from early developmental problems. The 7.62-mm Minigun was initially prone to stoppages – during one better-than-average test, it scored 237 hits out of 269 rounds fired, but then jammed. The Minigun eventually became as good a performer as any other, but was not included in the final design. At one point the Army was considering replacing the 30-mm cannon with the XM-188 30-mm 'rotary-barrelled gun'. At first the 30-mm gun jammed every two or three rounds, and intensive efforts improved this rate only to every 25 rounds. Eventually, a mean time between jams of 3,000 rounds was achieved.

Each wing had two hardpoints, coupled with two 'shoulder' pylons on the fuselage, all stressed for 2,000 lb (907 kg). Provision was made for underwing TOW missiles and up to 152 2.75-in (70-mm) rockets on the remaining four hardpoints. TOW would be carried in two three-missile pods on the inboard pylons. With two TOW pods fitted, 114 rockets could be carried in four pods. By late 1968 successful TOW firings had been made from a Cheyenne in flight, at the Yuma proving ground.

As the programme advanced, Lockheed proposed the addition of a moving map display, Doppler/INS navigation fit, a five-axis automatic flight control system, ECM systems, a station-keeping radar for all-weather formation flying, low-light-level TV and even a podded terrain-following (terrain-avoidance) radar on one of the underwing stations. One of the most important pieces of mission equipment would be what was originally described as an 'active night vision system' for target acquisition. Original plans investigated the use of a laser illumination system that would 'light up' targets on the battlefield. Other proposals called for the use of an LLLTV system. Advances in the emerging field of infra-red optics meant that these concepts were sidelined in favour of what would become one of the very first airborne FLIRs (Forward-Looking Infra-Red). Hughes Aircraft was chosen to develop a FLIR, to be known as PINE (Passive Infra-red Night Equipment). Outline plans called for the PINE to be mounted inside the aircraft on the swivelling gunner's station, slaved to the sight so that targets could be acquired and weapons directed against them, at night. No decision was ever reached as to what night-vision equipment to give the pilot, with the lower-resolution LLLTV solution being the front-runner. But, before any final decision could be made on these systems, the need for them disappeared.

By late 1968 the US Army had reactivated the 3rd Aviation Company in preparation for service testing of the Cheyenne, due to commence in mid-summer 1969. Airworthiness testing, some 200 hours, would first be conducted at Edwards AFB from January 1969, but the Army was already gearing up to begin Cheyenne crew training at the Fort Hunter/Stewart AFB complex. Experienced HueyCobra pilots drawn from Vietnam would lead the courses.

Disaster

The tragedy that marked the beginning of the end for the Cheyenne occurred on 12 March 1969. During a high-speed test flight near Carpinteria, off the Californian coast, the No. 3 prototype (66-8828) went rapidly out of control and crashed into the Pacific ½ mile (800 m) from the shore. The Cheyenne had been accompanied by a chase plane which was recording the flight and the two had been flying at approximately 2,500 ft (762 m). On that day the AH-56 was in the hands of Lockheed test pilot David Beil. As the chase plane looked on, the Cheyenne's main rotor tip plane began to blossom rapidly. Within seconds the rotor was

In all but take-off, landing and low-speed flight, the Cheyenne was effectively a fixed-wing aircraft with a pusher propeller. One important difference was that manoeuvring was done with the main rotor, allowing the wing to be small and without control surfaces.

One of the Cheyenne's selling points was its comparative ease of quick maintenance turnaround. The sponsons made a useful work platform, reducing the need for additional ground support equipment.

Beginning in March 1972, Lockheed pilots trained Army aviators in flying the AH-56 prior to final Army evaluations at Hunter-Liggett Army Air Field in central California. The Bell KingCobra and Sikorsky S-67 were also being tested.

oscillating out of control and the blades sliced into the pilot's canopy and then chopped off the tailboom. Beil was killed instantly. All the Cheyennes were subsequently grounded.

At the time of the crash the Cheyenne test fleet had achieved about 450 flight test hours, but in that time many changes had been made to the aircraft. Some sources at the time alleged that the power system alone had gone through as many as 450 modifications, with consistent difficulties occurring with the transmission. Programme insiders remember that there were difficulties, but that problems were no more serious then those found at a similar stage in any test programme. The Cheyenne's wing shape had been modified with a much extended root chord (increased by 50 per cent), to try to solve some of the high- and low-speed handling problems that had been encountered. Problems remained with the onboard systems, such as the heading and attitude reference system under development by General Precision Systems. Teledyne Ryan had solved a series of problems that had arisen with the weapons control system during 1968, but not before the Amy had considered allocating another contractor to the job. All of these troubles had not been without their cost, and the unofficial flyaway cost of the Cheyenne had risen to $2 million.

Public dispute

On 10 April 1969 a letter signed by Joseph A. Murray, the Army's AH-56 contracting officer, and approved by General William B. Bunker (one of the Cheyenne's strongest supporters and regarded by many as the father of modern US Army Aviation) was issued to Lockheed. It revealed that, behind the scenes, a major dispute had developed between the Army and the contractor, but now the dispute would be played out in public. The letter read, "You are hereby notified that you have 15 days after receipt of this notice to satisfactorily demonstrate in writing your ability to cure your failure to make satisfactory progress toward the production and timely delivery of aircraft which will meet contractual requirements. Such demonstration should include your specific plans to effect timely cures for the known technical problems." By this stage, however, the Cheyenne test programme was no longer a black and white situation. Misleading and incorrect information was appearing in the press, seemingly calculated to paint the aircraft in as bad a light as possible.

The Army announced that Lockheed had fallen seriously behind its performance guarantees as problems with the Cheyenne mounted, and Murray's letter went on to list those problems. Reportedly the Cheyenne suffered from: "Critical 0.5P unstable rotor oscillations occurring in the aircraft's operational flight envelope". A 0.5P condition is a sub-harmonic vibration occurring once every two rotations of the main rotor (and universally known to pilots as the 'half P hop'). Such vibrations could impose stress on the rotor system and ultimately cause it to fail – however, to call it 'unstable' was unfair. This implied that it was a dangerous, divergent condition instead of an undesirable, but clearly identified, one. A pilot encountering the 'half P hop' had to first identify it correctly and then slow the aircraft down so that the oscillation would slow, too, and finally damp out. The oscillation itself was a result of the small size of the original control gyro, which had insufficient polar inertia to control the blades under certain circumstances. This problem was quickly identified, and later eliminated by the Improved Control System (ICS).

The Army's letter then cited, "1P and 2P rotor instabilities at certain rotor mast bending moments and rotor rpm that have been experienced in autorotational landings" – at low speeds the rotor was starting to 'flap' (vibrating at a rate of once or twice per main rotor rotation) as the blades lost their stiffness and became more flexible. Despite the Army claims, test pilot Don Segner cannot recall this condition ever arising during autorotation tests.

The report went on to list, "Excessive swashplate cyclic travel permitting main rotor-tailboom interference during ground operations and autorotational landings" – the flexible swashplate platform on which the rotor mast sat was proving too flexible and the main blades had once hit the aircraft. These claims, and others, which were reported in the technical aviation press at the time, cannot now be validated, and all those who flew the aircraft flatly refute any suggestion that such problems ever occurred.

The Cheyenne once suffered a blade strike on the ground which was attributed to excessive movement of the cyclic. The Cheyenne, though, already had a control force centring system to prevent such incidents, and the blade strike was caused by someone who was not a pilot undertaking control measurement tests.

The Cheyenne did suffer from drag which reduced promised performance. It was overweight, which hit performance and manoeuvrability. It was prone to power train (transmission) problems and main rotor problems, and subject to annoying rates of vibration (although vibration was generally low, the 4P and 8P vibration naturally associated with a four-bladed rotor which destabilised the gunner's sight).

Schedule slippage

Lockheed admitted that there had been problems, which were only to be expected with such an advanced aircraft, and officially stated that the Army letter was simply a standard notification procedure. To solve some of the dynamic problems, the suggestion was made to raise the main rotor mast by 6 in (15 cm), but this was not an optimum solution as it would degrade the aircraft's handling. To its credit, Lockheed made progress towards tackling many of the AH-56's flaws, but at the unavoidable cost of schedule slippage, which pushed production start to December 1969 and introduced a delay of up to 11 months in the actual certification date.

Other forces then came into play. The newly installed Republican administration of President Richard Nixon was keen to rid itself of the procurement and managerial policies of the outgoing Lyndon Johnson. The Army could see that the rising cost and slipping schedule of the AH-56 would not be cleanly solved and knew that it would come under severe Department of Defense pressure to 'review' the programme. There were many within the organisation who were indecently hasty to do so. As a result, on 19 May 1969, the production portion of the Cheyenne programme was cancelled on grounds of 'default of contract' with respect to

One of the unique characteristics of the rigid rotor system, aided by the pusher propeller, was the ability to hover over a spot with the nose in other than a level position. What looks like a conventional helicopter take-off here is in fact a nose-down hover.

Above and below: The sixth Cheyenne (66-8831) was given this rather exotic paint scheme in 1971-72 during the Army evaluations. By this time, the AH-56 was beginning to look like an operational aircraft, but the axe was about to fall.

performance and timetable. The loss to Lockheed was estimated at $900 million. As far as everyone was concerned, the blame lay squarely with the now-discredited total package procurement policy instigated by McNamara, from which the Army hastily disassociated itself. The McNamara ruling called for total costs to be agreed from initial development to final production, before a final service decision had been made or a prototype properly evaluated. Such a total package contract left no room for renegotiation if costs proved to be higher than expected (as they invariably do) – similar price disasters had hit the USAF's C-5 Galaxy, the SRAM missile programme and the F-111 avionics system. The Army had been reluctant to sign such a deal with Lockheed in the first place and would have preferred a separate development contract that would have allowed time for problem solving. Instead, it now had to choose between accepting an automatic production go-ahead of an 'unacceptable' aircraft, or cancelling it outright. The Army chose the latter.

Payback time

The development programme had cost approximately $90 million and, as the Army was claiming a default, it sought the return of an additional $54 million that had been paid for long-lead production items. General Betts, who had been present at the roll-out of the Cheyenne, went on record as saying that both the Army and Lockheed had been overly optimistic in believing that the technological hurdles in the development of rigid rotor systems had been overcome. While Lockheed appealed the decision, the Army emphasised that the initial development contract remained in force; this threw a lifeline to the Cheyenne.

Controversial report

Bitter controversy boiled up again in October 1969 when the Army's accident investigation board released its report into the March crash and levelled a new series of accusations against Lockheed. The Army report alleged that, prior to the fatal flight, the Cheyenne had never been flown "at a rotor speed of 94 per cent". This claim, widely printed at the time, mystified Don Segner who remembers that the Cheyenne was routinely flown at 100 per cent rotor speed, from the earliest days. According to the Army, the vibration problems with the main rotor ensured that this flight was a critical excursion into an area of the flight envelope that was known to be dangerous, but not enough precautions had been taken. The Army said that intentional 0.5P oscillations had been induced during the flight, despite warnings against such action. No telemetry was provided for the flight and the Army report concluded that "LCC [the Lockheed California Company] failed to exercise due care and judgement in the planning and execution of flight 288 and, in doing so, failed to adhere to an acceptable level of sound industrial practice".

Those involved with the programme recall that aircraft 1002 was telemetered, but at that time such systems were of limited value in any case. Don Segner remembers that while the 'half P hop' phenomenon was one to be wary of, it did not represent anything like the danger attributed to it – in the hands of an experienced pilot. Furthermore, the Cheyenne was fitted with both a trigger-controlled friction brake on the collective and pilot-adjustable mechanical friction on the collective system to prevent any accidental 'collective bump' that might trigger the oscillations.

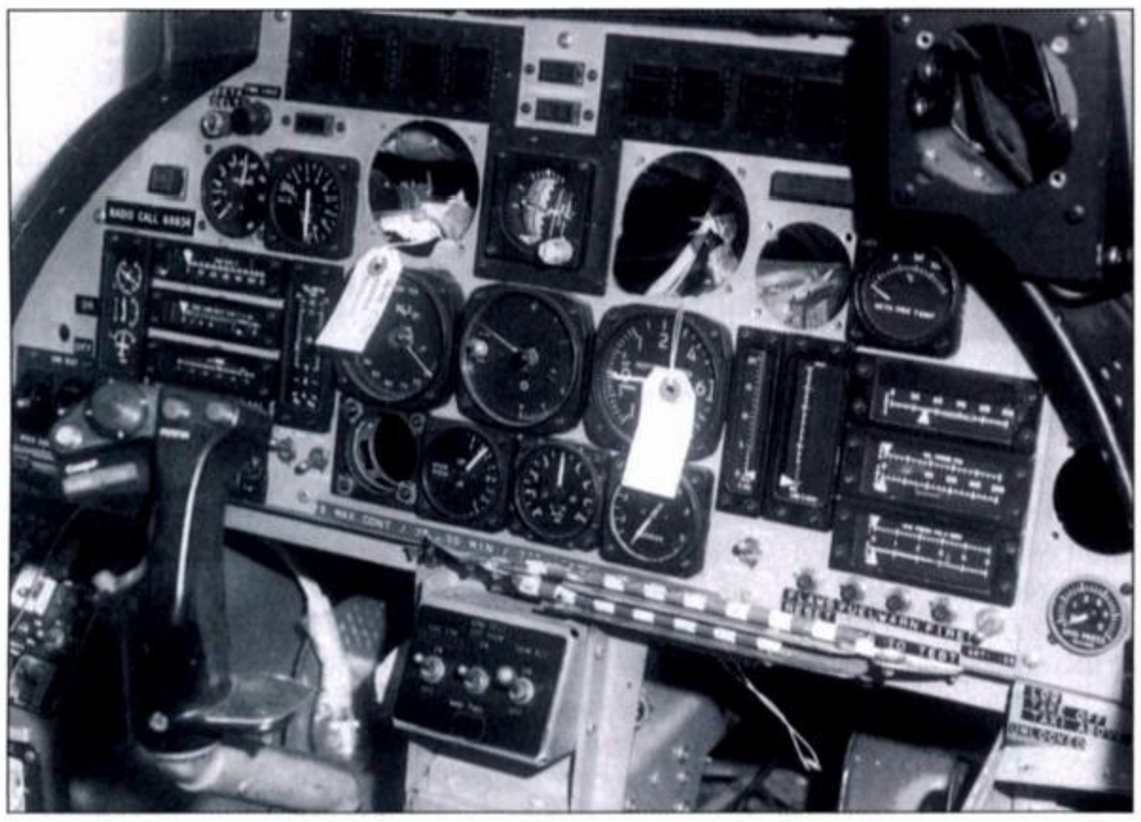
The Army wanted the Cheyenne to make the most of its speed and terrain masking for self-defence. Few helicopters since have been able to match the Cheyenne's ability to maintain steady flight at 200 kt (370 km/h) as low as 15 ft (4.6 m) above the ground.

The Army evaluated the Cheyenne's performance against various anti-aircraft weapons threats at the Hunter-Liggett Military Reservation, in spring 1972. The trials tested the AH-56's survivability in a hostile environment populated with AAA, armoured vehicles and other aircraft. Here, the test aircraft uses the terrain and its new camouflage to good effect

Lockheed's public rebuttal to the Army board, by Donald M. Wilder, executive vice president, said, "I must take vigorous exception to. the opinion expressed by those who signed the report in question – an opinion the company believes cannot be supported by the facts. The safety of a pilot and his aircraft are primary considerations in developing any of our test programmes. Test flying is a meticulously planned procedure, advancing step-by-step into the unknown through a co-ordinated programme of laboratory testing, computer analysis, and flight, and a certain amount of risk is recognised to be inherent in every test programme on a truly advanced aircraft. The flight was not exploring a new speed regime, but one that had been safely flown by test pilot Beil in this aircraft. The flight was made at a speed of approximately 230 mph TAS [370 km/h]. Previously, this aircraft had flown at a speed of 245 mph [395 km/h], in level flight, and, in a slight dive, had reached 257 mph [414 km/h]." It was true that LCC had been pushing for progress with the envelope expansion work and that some on the programme had reservations about the way test flying was being conducted but further investigation would conclude that the crash was indeed a unique incident.

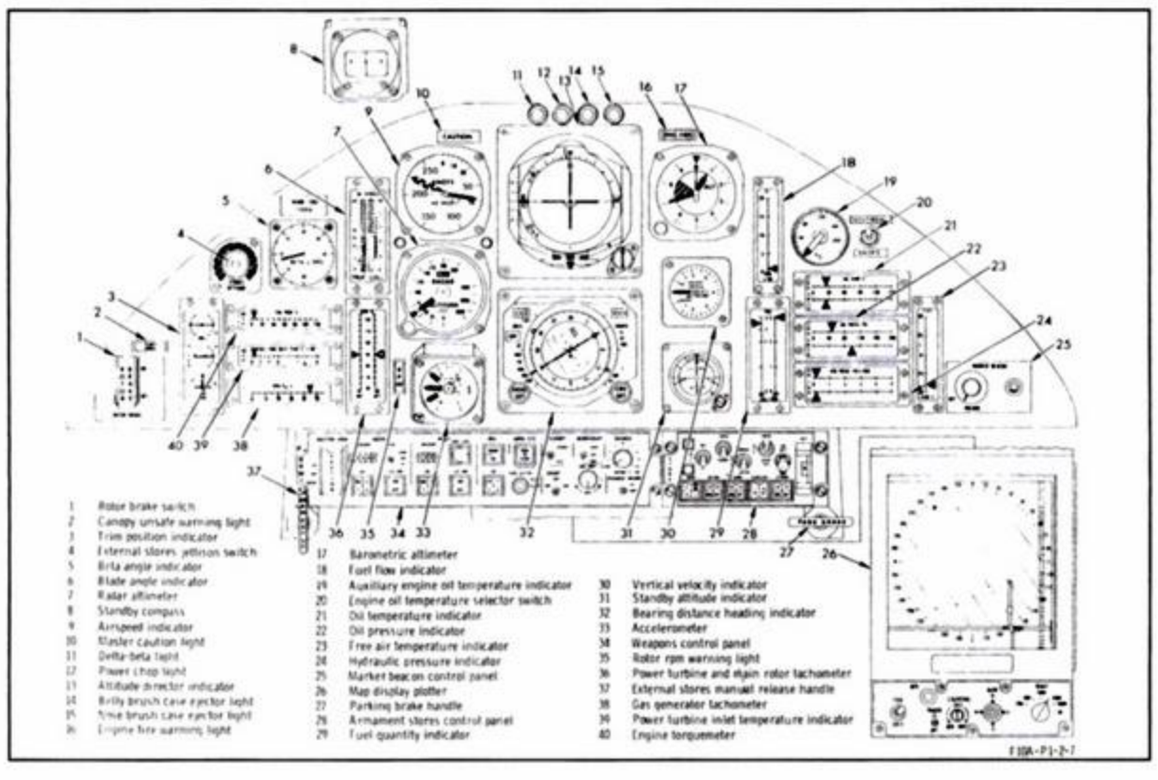
Continued investigation by Lockheed, the Army, the FAA and the Stanford Research Institute began to uncover more details of the of the crash. Beil's test card for the day had called for him to pulse the controls at a given (high) speed to excite the 'half P hop' and see how far it would go before becoming divergent. Previous testing had indicated that the risk of divergence was low, and flight test experience showed that any serious effects could be overcome by slowing, stabilising and allowing the oscillation to subside. The crucial factors

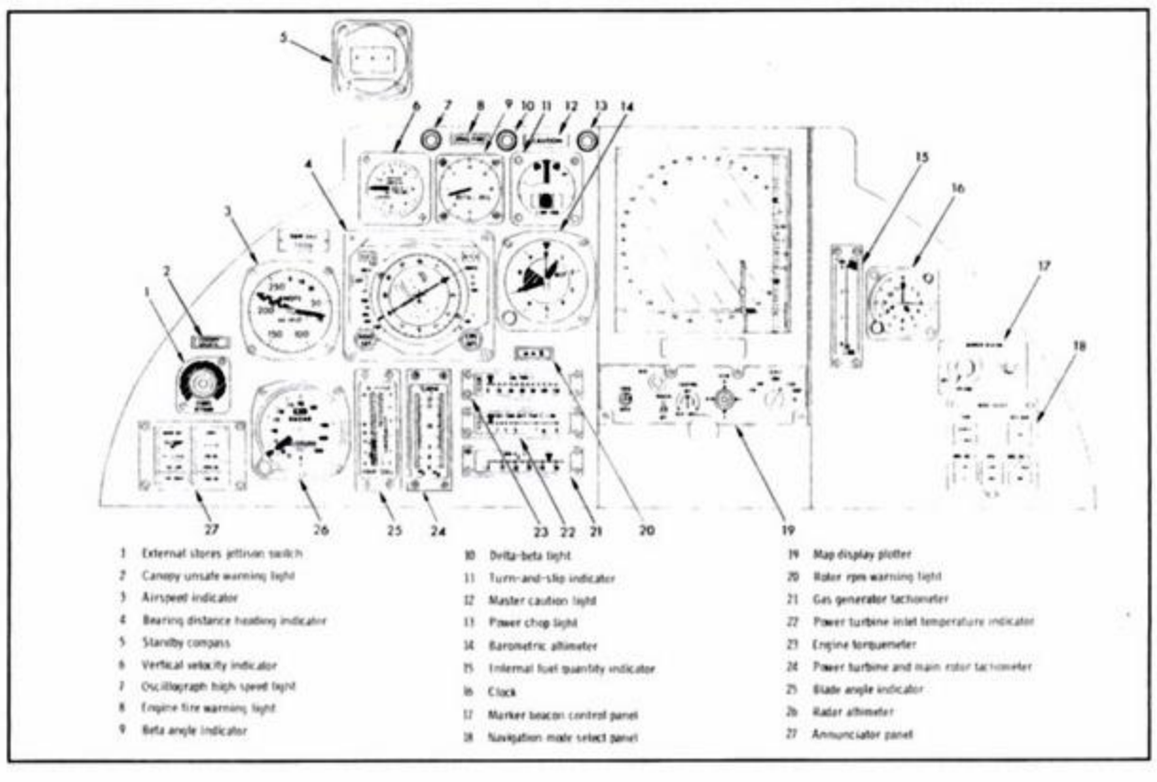
Cheyenne cockpits



The pilot's (rear) instrument panel of the ninth aircraft, with some instruments removed, is shown above. The schematic diagram below shows this basic layout with some minor variations.

The gunner's cockpit was dominated by the weapons sighting mechanism with its twin handgrips (not shown). The tactical roller map display is shown above in close up . The 'bug' indicated the AH-56's position.


1 Rotor brake switch
2 Canopy unsafe warning light
3 Trim position indicator
4 External stores jettison switch
5 Beta angle indicator
6 Blade angle indicator
7 Radar altimeter
8 Standby compass
9 Airspeed indicator
10 Master caution light
11 Delta-beta light
12 Power chop light
13 Attitude director indicator
14 Belly brush cave ejector light
15 Nine brush cave ejector light
16 Engine fire warning light
17 Barometric altimeter
18 Fuel flow indicator
19 Auxiliary engine oil temperature indicator
20 Engine oil temperature selector switch
21 Oil temperature indicator
22 Oil pressure indicator
23 Free air temperature indicator
24 Hydraulic pressure indicator
25 Marker beacon control panel
26 Map display plotter
27 Parking brake handle
28 Armament stores control panel
29 Fuel quantity indicator
30 Vertical velocity indicator
31 Standby attitude indicator
32 Bearing distance heading indicator
33 Accelerometer
34 Weapons control panel
35 Rotor rpm warning light
36 Power turbine and main rotor tachometer
37 External stores manual release handle
38 Gas generator tachometer
39 Power turbine inlet temperature indicator
40 Engine torquemeter


1 External stores jettison switch
2 Canopy unsafe warning light
3 Airspeed indicator
4 Bearing distance heading indicator
5 Standby compass
6 Vertical velocity indicator
7 Oscillograph high speed light
8 Engine fire warning light
9 Beta angle indicator
10 Delta-beta light
11 Turn-and-slip indicator
12 Master caution light
13 Power chop light
14 Barometric altimeter
15 Internal fuel quantity indicator
16 Clock
17 Marker beacon control panel
18 Navigation mode select panel
19 Map display plotter
20 Rotor rpm warning light
21 Gas generator tachometer
22 Power turbine inlet temperature indicator
23 Engine torquemeter
24 Power turbine and main rotor tachometer
25 Blade angle indicator
26 Radar altimeter
27 Annunciator panel

were for the pilot to recognise the onset of the condition and to then stop moving the controls – which would not be his natural reaction. David Beil instead became the victim of a pilot induced oscillation (PIO). As he tried to stop the vertical oscillation of the Cheyenne by moving the collective, his control movements took effect in the fraction of a second when the aircraft had actually swung back and was moving in the direction to increase the amplitude. As a result, the oscillation increased as he accidentally 'fed' it.

Research after the crash on a simulated control rig duplicated his control inputs; the test rig "went wild" until the controls were released. As in most PIOs, Beil seemed not to be aware that it was being driven by his arm on the controls. Once the oscillation had been induced it continued rapidly until the rotor system reached approximately ±3.5*g* and exceeded its limits. It also appeared that Beil was flying with all the collective friction and inhibiting systems turned off. Without this vital safety restriction, his hand and arm acted as a 'bob weight' – a forcing function – on the collective, driving the vertical oscillation into an ever-increasing amplitude. Had he let go, and the normal friction systems been in place, the Cheyenne would probably have recovered. As it was, the Cheyenne entered a vertical plunge that Beil did not recognise and could not control.

Funding fight

The Cheyenne stayed alive because the promise of the aircraft was too great to be ignored, and both the Army and Lockheed felt that its problems could be solved, though they disagreed about how and when. In spring 1969 the House of Representatives approved an Army request for $17.6 million for continued research and development in the FY71 budget (1 July 1970 to 30 June 1971). In June 1970 this funding was deleted by the Senate Armed Services Committee, but that decision had to be approved by a full Senate vote. At the same time, a parallel budget request – $17 million for advanced helicopter development – was approved and the Cheyenne programme continued to draw on existing funding to progress. By this time, Lockheed was embroiled in deepening financial problems of its own and was involved in claims and counter-claims covering $1 billion of defence contracts with the US government. In March it asked for $640 million in interim funding or it would be unable to complete the work then underway.

Suggestions that the Army wanted to fully reinstate the AH-56 production plan resurfaced by the end of 1969. Government officials expressed their satisfaction at the progress made by Lockheed and support for the Cheyenne remained high in the military. Three of the original 10 prototypes were dedicated to this renewed test effort, one of which (1009) was fitted with a downwards ejection seat (the front seat) derived from the F-104. A fourth AH-56 (1008) was being used as a non-flying avionics testbed and was later joined by a second. Another airframe, the No. 10 prototype (66-8835), had been accidentally destroyed in September 1969, during wind tunnel testing at NASA Ames Research Center, Moffet Field. The surviving three Cheyennes remained in storage at Van Nuys.

By August 1970 the three airworthy Cheyennes had logged 50 hours of renewed flight testing, and were being referred to by some sources as AH-56Bs on account of the improvements and modifications that were being made to them. The combined total for all Cheyenne test activities was then 1,300 flights over 700 hours. Plans to achieve FAA certification were abandoned, and the Cheyenne now chased Army airworthiness qualifications alone. Successful weapons testing was undertaken at the Yuma proving ground where the No. 6 aircraft demonstrated its ability to simultaneously hit two targets, one on either side of the aircraft. The first live TOW launches were made from the hover and in forward flight, with only one miss. In the end, the complex avionics and fire control system development proved to be the most straightforward aspect of the programme. By 23 October the Cheyenne had recorded a total of 1,578 flights over 801.4 hours.

The flight envelope was gradually extended from 130 to 190 kt (150 to 218 mph; 240 to 351 km/h), although by October 1970 only one aircraft (No. 9) had all the modifications required for such performance, including a revised rotor blade configuration that changed the sweep-back angle from 2° to 4°. The aim was to progress to 200 kt IAS in level flight at Yuma, which would equate to 217 kt on a standard day (59°F/15°C at sea level) – close to the original specification of 220 kt (253 mph; 406 km/h). The aim for production aircraft, which would feature reduced drag, was the full 220 kt.

Vibration cures

Modifications to the collective booster package and the pitch arm that connected the gyro to the main rotor finally eliminated the 0.5P

Cheyenne Chase

As Army evaluation of the Cheyenne approached, the Edwards-based unit tasked with the trials, the Army Aviation Engineering Flight Activity (AAEFA), sought an aircraft for chase duties that could manoeuvre through much of the AH-56's speed range. At first, a Beech U-21 Ute was evaluated, but rejected, and T-28B Trojans were used briefly before being replaced by three Cavalier-modified F-51D Mustangs in 1968. The second and third aircraft had been modified to Cavalier Mk 2 standard with wingtip tanks and a taller fin. All three had a second seat for a cameraman or observer. In 1972, with the final termination of the AH-56, the aircraft were assigned other duties, finally retiring in the mid-1970s, more than 35 years after the Mustang had entered Army (USAAF) service.

Above: The first chase aircraft used in the Cheyenne test programme were four ex-Navy T-28B Trojans acquired in 1966. Despite some advantages, they were found unable to match the acceleration capabilities of the AH-56 and were replaced by F-51D Mustangs.

Above left: The first of the three F-51Ds used for AH-56 chase duties is seen in May 1973 at Edwards AFB. Today it is preserved at Fort Rucker, together with a Cheyenne.

One of the many requirements met by the Cheyenne was the ability to hover at high altitude. Trials were conducted at Mammoth Mountain, in the Sierra Nevada range, California, in 1970. The small Mammoth Airport, base for the tests, was over 8,000 ft (2438 m) up, and hovering was demonstrated at up to 11,000 ft (3353 m).

The new AMCS (Advanced Mechanical Control System), first flown in 1972, solved most of the Cheyenne's control problems, but time was running out for the programme. The AMCS involved some rotor head changes.

vibration problems that had caused the crash. The 1P and 2P instabilities experienced on the ground were cured by changing the inplane frequency of the blades, accomplished by shaving metal from the leading and trailing edges of the rotor hub. To fix the problem of inadequate control authority in the hover and sideways flight, the tailrotor direction was reversed. All these changes were implemented on the No. 9 aircraft, along with a strengthening of the drive train that allowed the engine to be run at 3,925 shp (2928 kW) instead of the downrated 3,435 shp (2563 kW) in use previously. One less obvious change was the replacement of the sliding cockpit canopy with outward opening doors, which solved their annoying vibration problem.

By late 1970, in the light of the successful weapons and performance tests, the reorientation began of the AH-56 away from its one-time Vietnam role (US involvement in Southeast Asia was winding down by then) and fully toward the Soviet armoured threat in Europe. The Army felt that the AH-56's low-level, nap-of-earth capability could give it the edge in the European theatre, where it would be facing an even greater air defence threat than in Vietnam. A 15-hour series of Army flight evaluation trials was proposed for January 1971, to be followed by a further 25 hours in February. Formal acceptance trials would be run in April, paving the way for the reinstatement of production in October/December (for FY73). Contracts were (re)issued for TOW and night-sight development and, while the anticipated production go-ahead did not materialise, the test programme proceeded.

Uprated engine

It was decided to fit an uprated engine to the No. 9 prototype, a 4,300-shp (3208-kW) T64-GE-716, along with an improved control system that had been developed for the production-standard Cheyenne. Though the fixes made to the original control system had worked, pilots were still critical of the Cheyenne's performance in some aspects. The new, third-generation, advanced mechanical control system was intended to solve this problem permanently. However, it would require a 15-month evaluation process, including a return to ground and whirl rig testing. The AMCS was fitted to one aircraft (1007) and, in two months and 61 flying hours during 1972, Don Segner revalidated the entire flight envelope and won a positive report from the Army. With the addition of the AMCS, Segner firmly believed that the Cheyenne's design troubles were completely behind it.

Above: Among the famous faces to be briefed on the Cheyenne was astronaut Neil Armstrong, recently returned from the moon. Here, he is joined by Tony LeVier (left) and Don Segner.

Right: One of the Cheyenne's supporters in Washington was veteran congressman and champion of the armed forces Congressman Barry Goldwater, seen here with Don Segner. After the Cheyenne's final cancellation was announced, Goldwater tried in vain to have the decision reversed.

Extensions to the Cheyenne timetable were causing other troubles. Its mission avionics fit that had once been state-of-the-art was rapidly becoming outdated as smaller, lighter and more powerful computerised systems were developed. The essential Doppler attitude/heading reference system still did not work satisfactorily and the Army considered abandoning it altogether in favour of an unspecified alternative. By early 1972 the No. 6 aircraft was conducting weapons trials at Hunter-Liggett AAF and the No. 7 aircraft was in preparation to test modified and updated weapons systems.

As the fate of the Cheyenne continued to hang by a thread, the vultures began to gather. Not surprisingly, both Bell and Sikorsky made unsolicited offers of new aircraft to the Army, to replace the AH-56. Bell in particular had powerful supporters in the Army and could mobilise strong support behind the scenes in its campaign against the 'interlopers' at LCC. In January 1971 Bell began work on the Model 309 Kingcobra, a twin-engined development based on the AH-1J SeaCobra, aimed squarely at the Marines and the Army. Sikorsky developed the striking S-67 Blackhawk, an aquiline helicopter that went on to carve its own place in aviation history and won a world speed record. The Army decided to conduct a fly-off between the three types in 1972. Following combat evaluation trials of the AH-56 at Hunter-Liggett in June 1972, the Army was ready to conduct the three-way competition for a 'Heavy Attack Helicopter'. The Cheyenne had amassed a total of 2,660 flights over 1,550 hours. The Senate Armed Services Committee was still refusing to approve funding for the FY73 budget and Congressional disapproval over the acquisition of seemingly similar aircraft by the Army, Air Force and Marines (AH-56, A-9/A-10 and AV-8 Harrier) was mounting.

TOW troubles

One unfortunate incident may have been the final nail in the Cheyenne's coffin. The Senate Armed Services Committee came to Yuma to witness a fire-power demonstration by the AH-56 which included two TOW missile shots. Up to that time the Cheyenne had fired over 130 TOWs without a single failure, but on that occasion the first missile flew straight into the ground. Though the second TOW hit the target, in the minds of the Committee the damage was done. The Army struggled to explain that the TOW had an official failure rate of 10 per cent and not one missile had ever failed previously and that, in any case, it was a problem with the weapon rather than the aircraft; but, it was to no avail. The fly-off was completed in July and on 9 August 1972 the Army finally, and unexpectedly, pulled the plug. The termination of the project came as a complete shock to those working on it. All were convinced that the technical troubles with the Cheyenne were far behind them and there had not been the slightest rumour that the AH-56 was finished.

The Army took a different – and to some an inexplicable – view. None of the three aircraft

Cheyenne production and fates

Serial	c/n	Test function	Fate (where known)
'17501'	–	Mock-up	
66-8826	187-1001	Ground Test Vehicle	Noted derelict Aberdeen Proving Ground 1974
66-8827	187-1002	Basic flight test	Fort Polk Military Museum, La.
66-8828	187-1003		Crashed Carpinteria, Calif. 12 March 1969
66-8829	187-1004		
66-8830	187-1005		Stored US Army Aviation Museum, Fort Rucker
66-8831	187-1006	Weapons integration	Gate guard Minn. ArNG, now at Don F. Pratt Museum, Fort Campbell, Ky
66-8832	187-1007	Weapons evaluation	US Army Transportation Museum, Fort Eustis, Va., now at US Army Aviation Museum, Fort Rucker, Ala
66-8833	187-1008	Non-flying avionics test	
66-8834	187-1009	Performance evaluation	
66-8835	187-1010	Non-flying test	Destroyed in wind tunnel 17 September 1969

Note: In addition to the GTV, two other unidentified airframes were recorded at Aberdeen in 1974

Although not apparent here, this Cheyenne is flying at an all-up weight of over 22,000 lb (9979 kg) during Army tests. This compares with the 17,650 lb (8006 kg) gross weight of the AH-64 Apache. Today's Apache is superior in most respects, with its sophisticated electronics and armour protection, but is a totally conventional helicopter and entered service over a decade later than the Cheyenne could have. The Army lost more than just those years of potential attack helicopter operation when the rigid/compound Cheyenne was abandoned.

available now filled its needs, said an Army spokesman, and the service would begin a whole new search for a whole new attack helicopter. The Cheyenne, it was said, had become 'too expensive, too unreliable and too unsuited to the needs of the future European battlefield'. The estimated cost of a Cheyenne had now exceeded $4 million and was heading for $5 million. The contention was that the aircraft could not yet fly and fight at night – which had become the most essential capability – and the devastating impact of the newly-introduced shoulder-launched infantry SAM sealed its fate. In a 'low-and-slow' environment, the Cheyenne presented too large a target, it had to get too close to the enemy, and it would not survive. The programme had cost an estimated $400 million. Though the Army knew it needed an attack helicopter, it had little political support, at least for the Cheyenne. One of the flying prototypes continued AMCS flight tests under an Army contract between January and March 1973 but, to all intents and purposes, the AH-56 saga was finished.

In 1967 Lockheed had predicted that its new "flying tank, incorporating the latest in rotary-wing aircraft design, backed by more than 30 years of Lockheed aircraft and weapons system experience, will become one of the best friends the foot soldier ever had." The 'flying tank' reference was at least accurate. The Cheyenne was roughly the same size as an F-4 Phantom, its rotor diameter being about 13 ft (3.96 m) greater than a Phantom's wingspan. Those involved in the programme remember it as one which produced a great aircraft but which was badly managed, poorly funded and became embroiled in a debate about Army roles and missions that completely obscured the capabilities of the AH-56. The crash further clouded the issue – many outside the programme saw it as a condemnation of the rigid rotor system, but in fact it was simply the tragic, but avoidable, result of an undamped control system.

Air Force opposition

The AH-56 attracted consistent opposition from the USAF, which had powerful political friends, and always struggled against the perceived technical and military superiority of fixed-wing aircraft in the close air support role. Even within the Army the Cheyenne did not have enough friends, and some of those who should have nurtured the project at times actively denigrated it. In the years since its cancellation, the Cheyenne has gained a reputation as something of a technical failure, but those who flew the aircraft dismiss these charges out of hand. In Don Segner's words, "we made a sweet bird out of it", and the advent of the redesigned AMCS made the AH-56 easily capable of sustaining +2.6*g* and -0.2*g* at 180 kt. Maximum attained speed in a descent was 242 kt (447 km/h; 278 mph). Segner even flew a continuous 720° turn at 2*g*, and at a constant altitude, as a performance guarantee test – something no other similar helicopter had done.

When the Sikorsky S-66 was eliminated from the AAFSS competition in 1965, some at Sikorsky felt that the decision was the best thing that could have happened to the company, as it forced Sikorsky to examine the way it did business and evaluate some of the radical technology and 'free-thinking' that the Lockheed design exhibited. There is no doubt that the Cheyenne had a major impact on helicopter technology. The rigid rotor experience that the Cheyenne developed influenced Lockheed experimental designs into the 1980s, and the mission systems that the AH-56 introduced – in particular the FLIR – became the staples of the next generation of attack helicopter. However, by the time the Cheyenne's problems had been solved (or their solution was in sight), the aircraft had gained a reputation as an 'Edsel' and no-one was willing to risk a career by championing it. Attention turned elsewhere, towards the US Army's Advanced Attack Helicopter competition of 1972, which gave birth to McDonnell Douglas Helicopters' AH-64 Apache – the supreme attack helicopter that the Cheyenne could once have been.

Robert Hewson

Surviving Cheyennes

After the termination of the AH-56 programme, the surviving eight aircraft met a variety of fates. One was displayed as a gate guardian by the Minnesota ArNG for some years, another at Fort Eustis, Virginia. They have moved to new homes at Fort Campbell, Kentucky and Fort Rucker, Alabama, respectively. A second Cheyenne is also in storage at Fort Rucker. Two aircraft and the Ground Test Vehicle were reported derelict at Aberdeen, Maryland as long ago as 1974, and have no doubt long since ceased exist. Another is displayed at Fort Polk, Louisiana. One aircraft is unaccounted for, but may also have met its fate in weapons tests at the Aberdeen Proving Grounds.

The sixth aircraft (66-8831) was preserved by the Minnesota Army National Guard for a number of years (below right). Today it is at Fort Campbell.

66-8832, Cheyenne no. 7, is seen in 1977 on display at Fort Eustis (above right) and 20 years later (below) at Fort Rucker.

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Picture acknowledgments

Front cover: Geoff Lee/British Aerospace. **4:** Aerospace, Glenn L. Martin Co. (GLM). **5:** via Stan Piet, GLM. **6:** GLM, Aerospace (two), via Stan Piet. **7:** via Stan Piet, GLM (two). **8:** GLM (two), via Stan Piet (five). **9:** via Stan Piet (two). **10:** via Stan Piet, USAF, GLM. **11:** via Stan Piet (two), GLM. **12:** via Stan Piet (two), Aerospace, via Robert F. Dorr. **13:** via Stan Piet. **14:** USAF via Larry Davis. **15:** Stephen Miller via Larry Davis, Norm Crocker via Larry Davis, USAF via Larry Davis. **16:** Marc Miller via Larry Davis, Barry Miller via Larry Davis. **17:** Terry Love via Larry Davis, Tom Hansen via Larry Davis (two), USAF. **18:** USAF (two), USAF via Larry Davis. **19:** USAF via Larry Davis, USAF, John Hoye via Larry Davis. **20:** USAF Museum via Larry Davis, USAF via Larry Davis. **21:** USAF via Larry Davis, Tom Hansen via Larry Davis (two). **22:** Tom Hansen via Larry Davis (two), USAF Museum via Larry Davis (two). **23:** USAF Museum via Larry Davis, Tom Hansen via Larry Davis. **24:** USAF Museum via Larry Davis, Joe McCusker via Larry Davis (two). **25:** Aerospace, Nick Williams via Larry Davis, USAF via Larry Davis. **26:** Aerospace, Jim Elkinton via Larry Davis (two). **27:** USAF via Larry Davis, Tom Hansen via Larry Davis. **28:** Frank Murray via Larry Davis (three), via Dave Menard/Larry Davis. **29:** via Marty Isham/Larry Davis, via Larry Davis (two), Barry Miller via Larry Davis (two), Bob McGarry via Larry Davis, Don Jay via Larry Davis, via Tome Brewer/Larry Davis. **30:** Al Piccirillo via Larry Davis, USAF via Larry Davis. **31:** USAF Museum via Larry Davis, Aerospace, History Office 56th TTW via Larry Davis, Jim Elkinton via Larry Davis. **32:** via Larry Davis, USAF Museum via Larry Davis (two), Chuck Worman via Larry Davis. **33:** USAF via Larry Davis, via Larry Davis, Lee Bracken via Larry Davis, Chuck Worman via Larry Davis. **34:** Andrew Brooks. **35:** Denis J. Calvert. **36:** Blackburn, BAe, RAF Museum. **37:** Aerospace (two), Blackburn, Charles E. Brown. **38:** Blackburn (three). **39:** Flight Refuelling Ltd, Blackburn (two). **40:** Fleet Air Arm Museum (FAAM) (two), Blackburn (two). **41:** FAAM (two), Michael Stroud, Royal Navy. **42:** RAF Lossiemouth, Aerospace, Blackburn. **43:** Aerospace (two), FAAM (two). **44:** RAF Museum, Aerospace (two), Blackburn, Simon Watson. **45:** R. J. Wilson/Aerospace, FAAM (two), Graham Pitchfork. **46:** Aerospace, FAAM (two), R. J. Wilson/Aerospace. **48:** FAAM (three), Aerospace. **49:** Royal Navy, FAAM (two). **50:** Hawker Siddeley (two), Michael Stroud (two), Aerospace. **51:** via T. Panopalis, FAAM, RNAS Lossiemouth. **52:** Hawker Siddeley (two), Herman Potgieter (two). **54:** Herman Potgieter (three), Aerospace. **55:** Godfrey Mangion, Aerospace, FAAM (two). **56:** FAAM (three), HMS *Eagle*, Lucas Aerospace via T. Panopalis. **57:** FAAM (two), J. D. R. Rawlings, Aerospace, Graham Pitchfork (two). **58:** Ministry of Defence (MoD) (three), FAAM. **59:** FAAM (two), Aerospace. **60:** Hawker Siddeley (two), Royal Navy via T. Panopalis, FAAM, Royal Navy. **61:** Royal Navy via Simon Watson, Aerospace, Graham Pitchfork, Hawker Siddeley. **62:** Aerospace, MoD (three). **63:** MoD (five). **64:** MoD, Hawker Siddeley (two), Chris Pocock, BAe via Michael Stroud. **65:** MoD, Aerospace. **66:** Hawker Siddeley via T. Panopalis, via Peter R. Foster, MoD via T. Panopalis. **68:** Blackburn, Aerospace, Denis J. Calvert. **69:** via Peter R. Foster, Ian Black, Terry Senior, David Donald. **70:** David Donald (two), Wing Commander Mike Heath (three), Richard L. Ward (eight), Mike Rondot. **71:** FAAM (four), Dave Donald (three), BAe Dynamics, Dave Willis, Peter R. Foster, Hawker Siddeley, via Peter R. Foster. **75:** Aerospace, RNAS Lossiemouth, Blackburn. **76:** David Donald, Denis J. Calvert, Paul Jackson (four), Keith Wilson (two), MoD, Godfrey Mangion, Graham Pitchfork. **77:** Keith Wilson (two), Peter R. Foster, David Donald (two), MoD. **78:** Peter R. Foster, MoD via T. Panopalis, Frank B. Mormillo, Robert E. Kling, MoD. **79:** MoD via Graham Pitchfork, Keith Wilson/SFB Photographic, Hawker Siddeley (two). **80:** via Peter R. Foster, Peter R. Foster, Denis J. Calvert, Ian Black, MoD. **81:** MoD (three), Hawker Siddeley, F. Housby. **82:** Marshall of Cambridge, Ian Black, MoD. **83:** MoD (two), Robert Hewson, Paul Jackson, Denis J Calvert. **84:** MoD, Graham Pitchfork (two). **85:** MoD, Cliff Knox, BAe. **86:** BAe, Ian Black, Chris Ryan, Paul Jackson. **87:** BAe Dynamics via T. Panopalis, Paul Jackson, BAe Dynamics, Sgt Rick Brewell/DPR via Graham Pitchfork. **88:** BAe via Peter R. Foster, Simon Watson, via Ian Black, Ian Black, Paul Jackson (two). **89:** MoD, Press Association (three). **90:** BAe Dynamics via T. Panopalis, Denis J. Calvert (two), MoD vias T. Panopalis, Mike Rondot. **92:** Keith Wilson/SFB Photographic, Cliff Knox. **93:** David Donald (three), Ian Black, Denis J. Calvert, Graham Pitchfork, Louis Vosloo. **94:** A. R. Robinson, via T. Panopalis, Chris Ryan. **95:** Chris Ryan, FAAM, Denis J. Calvert, Godfrey Mangion (two). **96:** A. R. Robinson, Denis J. Calvert, FAAM (two), Godfrey Mangion. **97:** Simon Watson, A. R. Robinson (two), Tony Lovelock via Chris Pocock, via T. Panopalis. **98:** Peter R. Foster (two), Denis J. Calvert, Godfrey Mangion, David Donald, F. Housby. **99:** RAF Germany (two), Denis J. Calvert (three), Peter R. Foster. **100:** Denis J. Calvert, Chris Pocock, RAF Honington via Peter R. Foster, BAe, Peter R. Foster, Terry Senior, A.R. Robinson. **101:** Denis J. Calvert, Terry Senior (two), Peter R. Foster, Aerospace, Paul Jackson. **102:** via T. Panopalis (two), F. Housby, Cliff Knox, Bob Munro via David Donald, Peter R. Foster (three), Terry Senior (two). **103:** Ferranti via T. Panopalis, Herman Potgieter, Hawker Siddeley, Louis Vosloo, Andy Heape via Chris Pocock. **104:** via Alfred Price, via John Weal (two), IWM. **105:** via John Weal (two), Nauroth via John Weal. **106:** Nauroth via John Weal, via John Weal. **108:** via Alfred Price, Nauroth via John Weal. **109:** Nauroth via John Weal (three). **110:** Nauroth via John Weal (three). **111:** via John Weal (three). **112:** Aerospace, via Alfred Price, Nauroth via John Weal. **113:** Bundesarchiv via John Weal (two). **114:** Nauroth via John Weal, via Alfred Price, via John Weal. **115:** via Alfred Price, Aerospace. **116:** Nauroth via John Weal, via John Weal (two). **117:** Nauroth via John Weal (three), Aerospace. **118:** Aerospace, via Alfred Price (two). **119:** Nauroth via John Weal (two). **120:** via Alfred Price (two), Aerospace, Korn via John Weal (two), via John Weal. **121:** via John Weal (two). **122:** via Alfred Price, Nauroth via John Weal. **123:** via John Weal (three). **124:** Michael Stroud, Imperial War Museum (IWM). **125:** Charles E. Brown Collection/RAF Museum, via Michael Stroud. **126:** Aerospace, Charles E. Brown Collection/RAF Museum (two), Charles E. Brown via Philip Jarrett. **127:** Aerospace, via Derek James, via Jon Lake. **128:** via Jon Lake, IWM. **129:** IWM (two), MoD, Aerospace (two), via Jon Lake, via Philip Jarrett. **130:** via Michael Stroud, RAF Museum, P. H. T. Green (two), MoD. **131:** Charles E. Brown Collection/RAF Museum, IWM (two), Aerospace (two), MoD, via Philip Jarrett. **132:** Charles E. Brown Collection/RAF Museum, via Graham Pitchfork, RNZAF, via Philip Jarrett (three), via Michael Stroud. **133:** via Michael Stroud, via Jon Lake, Martin-Baker via Del Holyland (two), MoD, via Derek James. **134:** via Philip Jarrett. **135:** Ministry of Supply via Jon Lake, via Michael Stroud, Aerospace (two). **136:** via Michael Stroud (two), Aerospace, Gloster. **137:** Aerospace (five). **138:** Jim Winchester, San Diego Aerospace Museum, Dave Ostrowski Collection via Robert F. Dorr (two). **139:** Lockheed, Don Segner. **140:** Lockheed (three), via Don Segner (two), via Skip Robinson. **141:** Lockheed, San Diego Aerospace Museum, Dave Ostrowski Collection via Robert F. Dorr. **143:** via Don Segner (two), Lockheed (three). **144:** Lockheed, Aerospace (four), San Diego Aerospace Museum. **145:** Lockheed (two). **146:** Philco via Dave Ostrowski (two), Lockheed (two). **147:** Lockheed (three), via Don Segner (three), Hughes (four). **148:** via Don Segner, Aerospace, Lockheed via Don Segner. **149:** Lockheed via Terry Panopalis, Lockheed, San Diego Aerospace Museum. **150:** via Don Segner (four). **151:** via Don Segner (two), Lockheed (two). **152:** Lockheed, via Don Segner. **153:** via Don Segner (three). **154:** via Don Segner (four), via Robert F. Dorr (two). **155:** Aerospace, via Don Segner (two). **156:** via Don Segner (three). **157:** via Don Segner, Robert F. Dorr, Robert Hewson, Dave Ostrowski.

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ISBN 1-86184-029-2

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